SCIENTIFIC MONTHLY

THE SCIENTIFIC MONTHLY

VOL. LXXIII JULY 1951 No. 1

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(*Photo by A. C. Smith, Smithsonian Institution*)

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Annual Meeting, AAAS, Philadelphia, Pennsylvania, December 26–30, 1951

Established 1872 as ***The Popular Science Monthly;*** since 1915 an official publication of the American Association for the Advancement of Science.

Publication office, Business Press, Inc., 10 McGovern Ave., Lancaster, Pa. Orders for subscriptions and requests for change of address should be directed to the Circulation Department, A.A.A.S., 1515 Massachusetts Ave., N.W., Washington 5, D. C. Subscriptions: $7.50 per year; single copies 75 cents. Four weeks are required to effect change of address.

Address all correspondence concerning editorial matters and advertising to THE SCIENTIFIC MONTHLY, 1515 Massachusetts Ave., N.W., Washington 5, D. C. The editors are not responsible for loss or injury of manuscripts and photographs while in their possession or in transit; all manuscripts should be accompanied by return postage. The American Association for the Advancement of Science assumes no responsibility for the statements and opinions expressed by contributors.

 Entered as second-class matter at the Post Office at Lancaster, Pa., December 30, 1947, under the Act of March 3, 1879. Acceptance for mailing at the special rate of postage provided for in the Act of February 28, 1925, embodied in paragraph (d-2) Section 34.40 P.L. & R. of 1948. Indexed in the ***Reader's Guide to Periodical Literature.*** The A.A.A.S. also publishes SCIENCE. Subscription and advertising rates on request.

Science and Technology

(From the Month's News Releases)

Salt-free Diet

New Armour meat products, in 5½-oz. cans, will contain only 30–50 mg sodium/100 g in contrast to 400–810 mg/100 g usually found in canned meats. First to be put on the market will be beef stew, beef hash, beef and gravy, chili con carne, meat loaf, and meat sauce. No chemicals are used in the Armour process, and the meat will be packed under U. S. inspection.

Underground Report

According to a report entitled *Underground Gasification of Coal in Post-War Europe,* the Soviets are producing 11 million cu ft of gas per hour, rated up to 465 Btu per cu ft. Italian and Belgian advances in the underground gasification method are also described. The report contains about 12,000 words, and charts and tables that were in the original. Copies are available at $15 each from Accurate Translation Service, 711 Woodward Bldg., Washington 5, D. C.

More Captive Audiences?

The Message Repeater, a midget-sized automatic tape recording machine that will repeat sales, advertising, or safety messages endlessly or at a predetermined interval, went into production last month. It will retail at $149.50 and can be activated by electrical or mechanical methods.

Chemical Catalog

Standard Scientific Supply Corp., 34 W. 4th St., New York 12, will send free upon request its new *Apparatus, Reagents and Chemicals for Clinical Procedures,* a 168-page catalog divided into sections on reagents, chemicals, standards and buffers, reagents and stains, culture media, and apparatus.

See Better, Live Longer

Jumbo lens tissues come in 800 sheets per packet, and can be dispensed from a paper-towel–type cabinet. Useful in workshops, laboratories, and refineries.

Mighty Midget

A small self-driven tractor unit will convert any hand mower to a power mower in five minutes. It is also adaptable to wheel hoes, yard carts, and lawn rollers. The price is $29.70, or $59.95 when equipped with a small gasoline engine.

Giant Chart

The Periodic Chart of the Elements is now available from Fisher Scientific Company in a 52″ × 72″ size. It can be read easily from any place in a large room. The giant size is $9.75, and the smaller (32″ × 22½″) $3.00, postpaid.

Flash

The Flash-O-Lens spotlights the work it magnifies. It is equipped with Bausch & Lomb lenses and uses standard dry-cell batteries. ($14.85, × 7.)

Increase the life of your flashlight batteries by rotating them when they are in daily use. Users of two-cell flashlights should have three sets and store those not in use in the refrigerator in a glass container. They must be thawed for about an hour to give maximum power.

For Seeing the Invisible

For use as audiovisual aids in classroom demonstrations and in laboratory analysis Blak-Ray high-intensity, long-wave ultraviolet lamps are available in 4- to 80-watt sizes. The fixture may be rested on a flat surface, mounted flush to wall or ceiling, or hung from brackets. The lamps require no installation and are Underwriters' Laboratories Approved.

Electronic translator is assembled by Bell Telephone Laboratories engineer as part of the dial equipment that will make possible cross-country dialing by individual subscribers. Starting this fall, Englewood, N. J., telephone users will be able to dial subscribers in eleven selected cities as far away as San Francisco.

Unesco Coupons

The validity of all Unesco Coupons for books, films, and scientific material has been extended for an indefinite period. All those now in circulation will remain valid until Unesco recalls them by public announcement, allowing a six-months' interval for return of the coupons.

Adhesive Tape Resistor

The National Bureau of Standards has developed a method whereby electronic circuits are first printed in narrow metallic bands on insulating bases, leaving a small gap where a resistance is required; one of the self-adhesive resistors is then cut and pressed into position. The tape resistor will withstand temperatures up to 200° C and in other electrical characteristics is similar to present film-type carbon resistors.

Safer Mines

Du Pont has announced the development of Chemechol, a nonexplosive method for breaking down coal. A steel tube closed at one end by a plug with electrical connections and at the other by a rupturable disk, holds a chemical unit that releases gas at pressures that break down the coal. Chemechol produces no flame and cannot be activated by small electrical currents or by mine lighting or haulage circuits. Neither can it be detonated by blasting caps or high-strength dynamite.

Banish Five-O'clock Shadow

Lazy-Shave, which is a compressed talc designed to conceal even a dark beard, can be applied in a few seconds. The manufacturer says that when it is applied immediately after a shave, a close-shave effect lasts hours longer than usual.

Chiggers

The new mosquito repellents containing dimethyl phthalate are also said to be effective as chigger repellents. It's still wise, however, to bathe in soapy water soon after exposure. In addition, ammonia, alcohol, or camphor applied to itchy spots may help. You can control chiggers in lawns for one or two months by using chlordane or toxaphene sprays at the rate of 2 lbs per acre or lindane at ¼ lb of active ingredient per acre.

What, No Patchcords?

"Ida" (for Integro-Differential-Analyzer) is the new and tiny (comparatively speaking) electronic brain. Small businesses, research laboratories, and universities that need an analog computer can buy Ida for $8,000. Low cost was achieved by the elimination of patchcords and other parts, and by the use of standardized, interchangeable parts and a minimum number of controls.

Message Taker

An automatic telephone-answering machine that comes in a three-piece unit will tell the caller when his party will return or where, in case of emergency, he can get service. It will take down telephone orders or serve as a handy portable dictation machine.

Robot

The Grasshopper is a bomb-shaped device that, parachuted from an airplane, will set itself up on six legs, periodically make and transmit weather observations, and serve as a radio marker beacon. It can also be adapted to send various other kinds of information. Originally designed by the National Bureau of Standards for the Navy Bureau of Ships, it has been further developed by Robert P. Bennett, of White Hall, Md., who has received a U. S. patent for his improvement.

Cool Off in the Sun

A white mat of tough plastic sheeting formed into a mattress of eight chambers may be used for sunbathing in the back yard or on the porch or beach. Four chambers are to be filled with water and four with air.

Autopositive Paper

A tough, durable, and highly translucent new drawing reproduction paper will withstand rough handling, can be handled on familiar reproduction equipment and in ordinary room light. Details are easily read through back of sheet. It comes in standard roll and sheet sizes and in widths up to 42 inches.

Cut Faster

A foam glass sanding block requires very light pressure, no scrubbing. Since it conforms to surface irregularities, Kwiksand makes it possible to sand an entire surface in a single operation. Each block has coarse and fine cutting surfaces, and as it wears down offers fresh surfaces until used up.

Tape Economy

A tape dispenser, adjustable (at the factory) for use with cloth or filament tapes, operates from a 110-volt lighting circuit, automatically measuring, moistening, and cutting off the exact length of tape required. Telephone-type dial.

Pointer

Pick up the Perfect Pointer and a brilliant light appears on the screen. Put it down and off goes the light. Weighs only 8 oz. and can be carried in briefcase or coat pocket.

Philately Division

The Smithsonian has prepared a revised listing, consisting of about 255 individual photographs, starting with the Columbian issue of 1893, of original material used on U. S. postage, commemorative, and duck stamps. A copy of the list may be obtained from the Smithsonian Institution, Washington 25, D. C. Enclose 12 cents to cover postage.

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The Vegetation and Flora of Fiji*

ALBERT C. SMITH

A specialist in the taxonomy of flowering plants, the author (Ph.D., Columbia, 1926) collected the material for his article on his two visits to Fiji (1933–34, 1947–48). Among his botanizing expeditions have been trips to Colombia, Peru, Brazil, and British Guiana. During these trips he prepared approximately 120,000 herbarium specimens; in between he has published more than a hundred technical papers, including floristic studies and monographs. He has been a staff member of the New York Botanical Garden and the Arnold Arboretum of Harvard University, and since 1948 has been curator of the Division of Phanerogams of the Smithsonian Institution.

THE first European discoverers of Fiji did not concern themselves about plants. The Dutch navigator Abel Tasman, who is credited with being the first white man to see any of the Fijian group, while steering a course from Tonga to the Indies in 1643, found himself entangled among reefs and islands in the northeastern part of Fiji. After a forced crossing of the dangerous Nanuku Reef, Tasman observed and charted about a dozen small islands, finally making his way into open water from one of the most hazardous mazes of reefs in the Pacific. He then left the region with all dispatch, and just in time, as a rising tempest would have made disaster inevitable.

Warned by Tasman's experience, navigators avoided the area for more than a hundred and thirty years. In 1774 Captain Cook, on his second voyage, approached the small island of Vatoa, in the southern Lau group. A few natives, presumably the first Fijians seen by Europeans, fled into the woods, but Cook's men left tools and trinkets for them on the rocks. Vatoa was the only Fijian island seen by Cook.

Credit for the discovery of the major islands of Fiji goes to that accomplished navigator William Bligh. After the much-described mutiny on the *Bounty* in the Tongan group, in 1789, Bligh and eighteen of his men, set adrift without firearms in a tiny launch, found the natives of Tofua Island so inimical that they set sail for Timor, 3,600 miles to the west. During this amazing voyage Bligh sailed right through the center of the Fiji group, followed by the southeast trade wind. He saw and charted with remarkable accuracy numerous islands, including the two major ones, Viti Levu and Vanua Levu. One imagines the emotions of the starving and thirsting men as they traversed the reef-strewn passage between these large islands. To their north they may have seen the mass of Mount Seatura, dominating western Vanua Levu; to the south lay the Kauvandra Range of northern Viti Levu, traditional home of the Fijian god Ndengei. But they were unable to seek food and water on those fertile shores because of the hostile natives, who pursued them in canoes. In 1792, un-

* Based in part on a paper delivered before the Section on Taxonomy of the Seventh International Botanical Congress, Stockholm 1950.

der more favorable conditions, Bligh again visited Fiji and charted numerous other islands; in all he is credited with discovering 39 islands in the group.

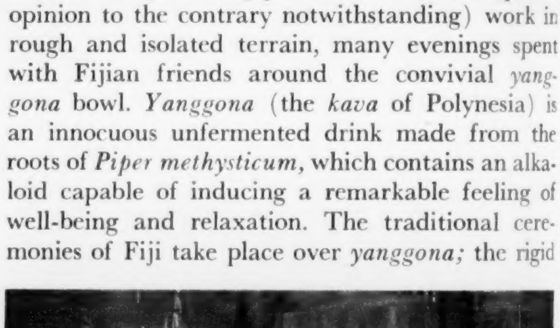
In the first decades of the nineteenth century disaster overtook the Fijians, in the form of renegade whites, muskets, and disease. The discovery of a species of sandalwood on Vanua Levu led to a few years of profitable looting by traders, to be followed by a period of trading in *bêche-de-mer*. The Fijians learned nothing good from the whites, and atrocities on both sides were the rule in most dealings. Not until events leading up to the cession of the group and its reluctant annexation by England in 1874 was anything like normalcy reestablished in Fiji.

The United States South Pacific Exploring Expedition, under Commodore Wilkes, brought the first scientific visitors other than navigators to Fiji. In 1840 the scientists of this expedition, including the botanists Brackenridge, Pickering, and Rich, made collections along the coasts of several islands; their material was studied by Asa Gray and is the basis of our knowledge of the Fijian flora. Preeminent among the several other botanical collectors who visited Fiji in the latter half of the nineteenth century was Berthold Seemann, who in 1860 made the extensive collections which, together with the Wilkes material, made possible the compilation of his *Flora Vitiensis*. This was a remarkably good work for its period, and it is still the only comprehensive flora of any archipelago in the vicinity.

In the current century several able botanists have collected in Fiji, among whom may be named im Thurn, Gibbs, Bryan, Parks, Gillespie, and Degener; their material is supplemented by valuable collections made by residents in the group. The writer has had the good fortune to spend eighteen months in Fiji during the course of two trips,† working on nine of the islands but concentrating on the two largest. The material assembled by various collectors in Fiji, although far from adequate for the preparation of a definitive flora, is nevertheless now more complete than for any other southwestern Pacific archipelago. Dozens of sizable islands in Fiji are still uncollected by a botanist, and on the larger islands great expanses of hill forest and grassland remain botanically unexplored; consequently a high percentage of novelties may be expected from every comprehensive collection of plants, and generalizations as to the floristic composition of the vegetation, although past the speculative stage, are far from final.

Every scientist whose work takes him to faraway and historically romantic lands faces the task of justifying his excursions to a certain type of acquaintance. Plant collectors are especially suspect in the public eye, for "picking flowers" does not seem an arduous or full-time task to many, and one's friends assume that ample time remains for dalliance in more unbotanical pursuits. A considerable degree of truth exists in such charges, tacit or otherwise; who is a botanist to ignore an opportunity for a minor sort of ethnological research? Among Fijians, especially, to remain aloof would be both foolish and difficult, for in no people are the arts of hospitality and friendship more pleasingly developed.

In casting through my remembrances of Fiji I recall, among the long periods of strenuous (public opinion to the contrary notwithstanding) work in rough and isolated terrain, many evenings spent with Fijian friends around the convivial *yanggona* bowl. *Yanggona* (the *kava* of Polynesia) is an innocuous unfermented drink made from the roots of *Piper methysticum*, which contains an alkaloid capable of inducing a remarkable feeling of well-being and relaxation. The traditional ceremonies of Fiji take place over *yanggona;* the rigid



Fijians preparing *yanggona*. Beverage is made from the powdered or grated roots of *Piper methysticum* by the addition of water. The coarse vegetable particles are then strained from the mixture by the use of hibiscus fibers. The *yanggona* bowl is traditionally made from a single piece of wood, usually from the leguminous tree *Intsia bijuga*. On Viti Levu the bowls have four legs, like that shown, but in Lau they may have six or more legs, suggestive of Polynesian influence; in Samoa the *kava* bowls are made with even more numerous legs. Also shown is the floor covering of woven *Pandanus* leaf strips, and the inner wall of closely tied reeds (*Miscanthus japonicus*).

† The first of these trips, in 1933–34, was made under the auspices of the Bernice P. Bishop Museum, the New York Botanical Garden, and Yale University; the second, in 1947–48, was sponsored by the John Simon Guggenheim Memorial Foundation and the Arnold Arboretum of Harvard University, with the aid of grants from the National Academy of Sciences and the American Philosophical Society.

A dance (*meke*) of the type known as *vakamalolo,* here performed by young men. This is a favorite type of *meke,* the action being limited to the upper part of the body, especially the arms and head, and carried out in unison by four to six dancers. The musical accompaniment is of blended voices of a chorus placed behind the dancers, usually singing some local legend; rhythm is provided by a single small wooden drum (*lali*). (Photograph from Mbua Province, Vanua Levu.)

ritual of presentation of a root to a distinguished visitor, the preparation and serving of the drink, the accompaniment of certain chants and hand-clapping, and the specified responses are fixed by custom in each locality. I remember the *meke*—a combination of dance and song—shown with such dignity and pride by those people of the outlying regions who have not yet succumbed to the tawdry substitutes for amusement offered by Europeans. In Lau, and in parts of Vanua Levu, each village has its traditional *mekes,* and the visiting scientist would be incurious indeed who did not spend some of his evenings enjoying this virile folk art. But most of all, perhaps, one remembers the country, the undisturbed hill forest in its many moods of calm and storm. One recalls the mist-drenched mountain crests, the exhilarating views over broken ranges or reef-fringed shores, the sunny days and the drenching rain, the quiet nights in mountain camps and the sudden, fragrant dawns.

Tourists have not yet discovered Fiji. Some travelers spend an hour or two at the Nandi Airport (a completely disillusioning part of the group); others visit Suva for a day and drive as far as the Rewa Delta, or they may even make a circuit of Viti Levu on a dusty but interesting 360-mile road; occasionally one takes the time to fly to Lambasa on Vanua Levu, or to visit Levuka by launch, or to see the fire-walkers on Mbengga. It is not my place to direct the attention of tourists to the more interesting and scenic parts of Fiji. On the contrary, that this beautiful country and friendly people may escape further exposure to Western civilization is one of my happiest illusions.

Vegetation

The least observant visitor to Fiji, provided he desists from buying silver trinkets and imitation war clubs in Suva and travels about the country, must note the striking vegetational difference between the "wet" and "dry" sides of the large islands. This difference, of course, is primarily the result of the interception of the prevalent southeast trade winds by fairly substantial land masses. Although the total land area of Fiji is slightly less than 8,000 square miles, the topography of the larger islands is extremely rugged; the highest elevation, 1,323 meters on Mount Tomanivi, is approached by numerous other hills. An examination of Tables 1 and 2‡ shows that rainfall differ-

‡ For access to the weather records that have been maintained in Fiji over a period of many decades, I am greatly indebted to Ralph Dyer, director of the Meteorological Department in Suva.

ences are a principal cause of the more obvious vegetational differences.

In these tables, the first five localities are on the windward sides of the large islands, and the last four are on the leeward sides. In the rain-forest (windward) area the annual average rainfall may range up to more than 200 inches, but in the grassland (leeward) area it does not much exceed 80 inches. The normal number of wet days shows significantly that some rainfall may be expected at least every second day, on the average, in the forested areas. Distribution of rainfall throughout the year is certainly one of the limiting factors for the vegetation. It is seen in Table 2 that rainfall during the wetter six months, November to April, is not much higher than during the drier months at the forest-area stations. In fact, statistics for the fifth station shown, on Taveuni, demonstrate that more rain falls during the dry season than during the wet season! However, on the leeward sides of the islands the rainfall may be negligible, and in some years essentially lacking, during the six months of the trade-wind season.

The leeward sides of the large islands, except for those portions of the coastal strip that are under irrigated sugar-cane culture, are characteristically covered with savanna and thickets of low, shrubby plants. In places the entire vegetation is a mixture of grasses, largely introductions that have successfully eliminated the native plants, sometimes dominated by a single species, such as *Pennisetum polystachyum* in parts of northwestern Viti Levu. Other common herbaceous or low shrubby elements belong to such families as Cyperaceae, Compositae, Leguminosae, Solanaceae, and Convolvulaceae; ferns of the genera *Gleichenia* and *Pteridium* have taken possession of considerable areas. Characteristic shrubs belong to the families Euphorbiaceae and Rubiaceae, and to such genera as *Ilex, Hibbertia,* and *Leucopogon.* Trees are not lacking in this dry area, two species of *Casuarina* being conspicuous; *Santalum yasi,* the Fijian sandalwood, was at one time a common plant of the dry slopes, but the depredations of traders in the early nineteenth century came close to eradicating it.

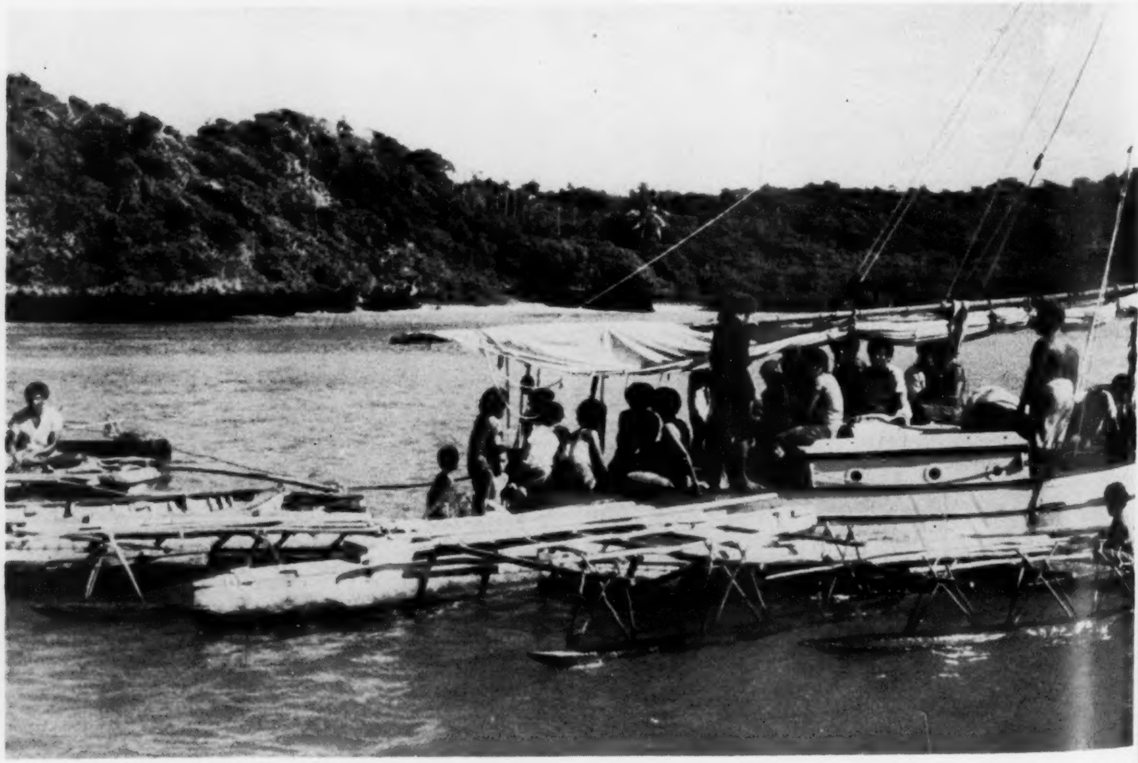
This dry zone of the large islands, which the Fijians call *talasinga,* is subject to frequent fires toward the end of the dry season. It is probable, indeed, that fire is an important agent in fixing the extent of the *talasinga*; in places it sweeps to the edge of the heavily forested areas, into which it does not seriously encroach. However, without annual fires it is probable that much of the *talasinga* would support a heavier growth of shrubs and low trees than it now does, although the fundamental differences in vegetational composition

A *meke* performed by women, describing a local legend in song and movement. They wear the traditional skirts of *ngatu* (tapa of Polynesia) over their "best" clothes. In the background is a typical Fijian house, thatched with the leaves of the reed *ngasau* (*Miscanthus japonicus*); the ends of the ridgepole are terminated by the caudex of a tree fern (*Alsophila* sp.). (Photograph from Mbua Province, Vanua Levu.)

A view from Koroyanitu, the summit of the Mount Evans Range, southward, showing the rugged and heavily eroded terrain of the *talasinga* (grassland) of western Viti Levu. In the distance is a similarly isolated range terminating in the forested Mount Koromba (Pickering Peak), with an altitude of 1,075 meters.

Another view from Koroyanitu, showing typically eroded hills of the *talasinga* of northwestern Viti Levu. The summits of these hills, above about 700 meters, are often heavily forested. In the distance is the central plateau of Viti Levu.

Tomanivi (Mount Victoria), the highest point in Fiji, with a summit elevation of 1,323 meters, lies near the northern edge of the extensive rain forest that covers central and southeastern Viti Levu.



Natives of Fulanga, in the southern Lau group, visit a trader's boat in the lagoon. Two or three such visits a year provide them with their only chances to obtain staples. (The limestone [background] of Fulanga is characteristically covered with a dense forest and is undercut at sea level.)

TABLE 1

RAINFALL STATISTICS OF SELECTED LOCALITIES IN FIJI

Place / Province / Island	Normal Annual Rainfall (inches)	Normal Number of Wet Days	Normal Rainfall (inches), Wettest Month	Normal Rainfall (inches), Driest Month
Suva Rewa Viti Levu	120.86	246.8	14.73 March	5.41 July
Vunindawa Naitasiri Viti Levu	140.10	175.6	17.16 December	4.14 July
Nandarivatu Mba Viti Levu	137.63	176.3	25.06 February	3.56 July
Yanawai Mbua Vanua Levu	202.33	237.0	20.01 May	13.14 June
Salialevu Taveuni	213.57	183.5	21.76 September	13.63 July
Lautoka Mba Viti Levu	69.06	107.0	12.20 March	1.92 July
Mba Mba Viti Levu	80.86	117.9	16.00 February	1.84 July
Penang Ra Viti Levu	79.31	129.6	13.88 February	1.93 July
Lambasa Mathuata Vanua Levu	81.82	129.8	14.16 February	1.79 July

between it and the rain forest appear to be climatic and not artificial.

The rain forest, the *veikau* of the Fijians, covers the entire southern and eastern portions of the large islands and most parts of the small islands, where not disturbed. This forest, like that of most wet tropical areas, has remarkable recuperative powers and will repossess cleared regions with reasonable rapidity. The shifting agriculture of the Fijians has, until recent decades, made little impression upon it, and one may hope that the greedier newcomers (European and East Indian) will limit their invasion of the Fijian forest. Arborescent elements are so diverse that I can here mention but a few characteristic families such as the Rubiaceae, Lauraceae, Meliaceae, Sapotaceae, and Myrtaceae, and the most frequently met genera, *Agathis, Podocarpus, Dacrydium, Balaka, Vitiphoenix, Piper, Myristica, Ficus, Pittosporum, Elaeocarpus, Evodia, Aglaia, Astronidium, Syzygium, Cyrtandra,* and *Psychotria.* Large herbs like *Alpinia,* climbing Araceae and bright-flowered species of *Medinilla,* epiphytic orchids, and the brilliant parasite *Amylotheca insularum* add to the profusion and density of this wet forest.

None of the Fijian hills is high enough to interrupt the continuity of the *veikau,* which on summits and crests is more modified by conditions of exposure than by temperature. As shown in Table 3, temperatures at the selected stations are fairly uniform. Nandarivatu, at an elevation of about 850 meters, has an average temperature only about 10° less than the coast. Even on the highest summits the temperature rarely falls below 40° F, and at sea level the highest temperature officially recorded has been 99° F. Higher elevations of the rain forest are usually characterized by the same generic elements as middle elevations, but on the often cloud-drenched crests one notes a greater profusion of epiphytic orchids, ferns, and bryophytes cloaking or even concealing the branches of gnarled shrubs and low trees. Genera characteristic of the Fijian mountain crests are *Peperomia, Elatostema, Coriaria, Crossostylis, Gahnia,* and *Freycinetia,* the last, a relative of *Pandanus,* often forming impenetrable thickets of interlaced stems and tough leaves.

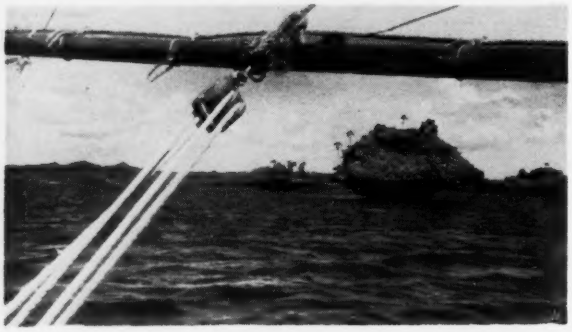
Plants of beach and mangrove swamp are in general widely dispersed throughout the tropics. Behind the Fijian beaches occur the usual pantropical or pan-Pacific grasses, interspersed with the common *Ipomoea pes-caprae,* here and there yielding to thickets with such components as *Pandanus tectorius, Cordia subcordata, Messerschmidtia argentea, Scaevola frutescens,* and other widespread

TABLE 2

SEASONAL DISTRIBUTION OF RAINFALL IN SELECTED LOCALITIES IN FIJI

Place / Province / Island	Normal Annual Rainfall (inches)	Normal Rainfall November–April (inches)	Normal Rainfall May–October (inches)
Suva Rewa Viti Levu	120.86	73.48	47.38
Vunindawa Naitasiri Viti Levu	140.10	94.03	46.07
Nandarivatu Mba Viti Levu	137.63	107.75	29.88
Yanawai Mbua Vanua Levu	202.33	103.67	98.66
Salialevu Taveuni	213.57	106.21	107.36
Lautoka Mba Viti Levu	69.06	51.47	17.59
Mba Mba Viti Levu	80.86	63.22	17.64
Penang Ra Viti Levu	79.31	60.93	18.38
Lambasa Mathuata Vanua Levu	81.82	64.88	16.94

the Kermadecs to include New Zealand and certain of its outlying islands. The two large islands of Fiji, Viti Levu and Vanua Levu, have central cores of deeply eroded plutonic rocks and are thought to be the remnants of an older continental mass. The occurrence of plutonic rocks, especially in islands such as Viti Levu, where the rocks are definitely in place, suggests that tremendous thicknesses of rocks have been removed by erosion. This in turn implies more extensive land areas. Even more significant is the widespread presence of metamorphic rocks, which demands powerful earth forces that surely could not have been generated on small isolated islands.



The lagoon of Fulanga is dotted with several hundred small, mushroom-shaped islets, undercut at the base. The palm growing here, *Pritchardia thurstonii,* is a Fijian endemic.

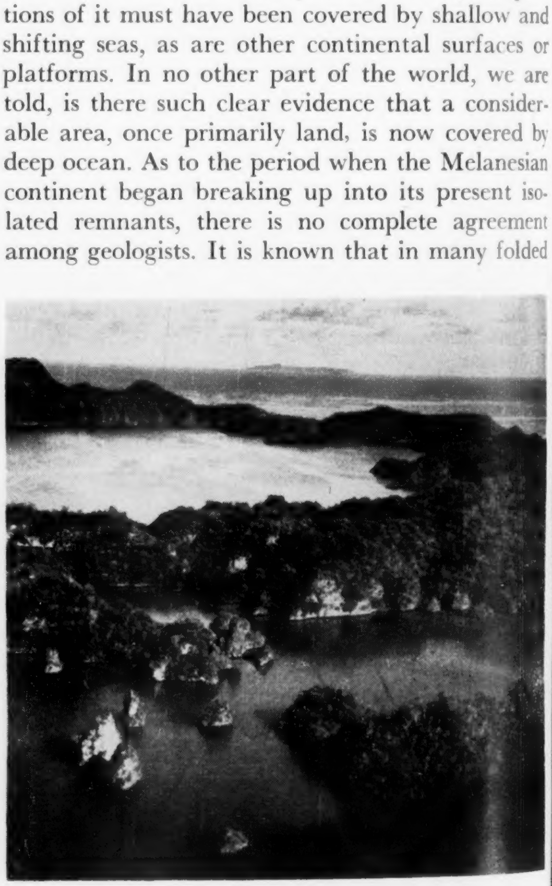
species. Mangrove swamps, occurring in estuaries along the coasts of the large islands, are characterized chiefly by species of *Bruguiera, Rhizophora,* and *Lumnitzera.*

The strictly oceanic islands in Fiji, mostly found in the Lau group in the eastern part of the archipelago, often have a volcanic core and portions composed of organic limestone. The volcanic areas have much the same vegetation as the *talasinga* of the large islands, whereas the limestone areas have quite different characteristics. They are often nearly devoid of soil but nevertheless support a dense covering of woody plants of diverse families. A feature of these limestone islands that impresses one, aside from the abrupt and picturesque contours of the land, is the dense bright-green of the vegetation. Many of the islands of Lau are upraised atolls, with large shallow lagoons containing numerous curious, mushroom-shaped islets, characteristically undercut at the base. A feature of these islets is the palm *Pritchardia thurstonii,* endemic to Lau.

Geological History

In discussing the origins and relationships of the flora of any region, it is of course essential to consider its geological history. Fortunately a modern geological discussion of Fiji is available, and for the basic facts here utilized I have called freely upon Harry S. Ladd's *The Geology of Viti Levu, Fiji.* The two types of islands recognized in the Pacific are oceanic islands, composed entirely of volcanic rocks and organic limestone or sediments derived from these, and continental islands, made up of plutonic or metamorphic rocks in addition to the types of rocks found on the oceanic islands. All the Pacific continental islands, it is believed, lie west of an imaginary line passing from Yap through Truk, New Ireland, the Solomon Islands, and Fiji to Tonga, thence southwestward through

It seems to be the consensus of geological opinion that Fiji and other archipelagos west of the line detailed above were at one time part of a Melanesian continent that connected Asia to Australia and extended eastward into the present Pacific basin. Of course, it is not assumed that this "continent" was always a land area, for portions of it must have been covered by shallow and shifting seas, as are other continental surfaces or platforms. In no other part of the world, we are told, is there such clear evidence that a considerable area, once primarily land, is now covered by deep ocean. As to the period when the Melanesian continent began breaking up into its present isolated remnants, there is no complete agreement among geologists. It is known that in many folded



A portion of the Bay of Islands, northern Vanua Mbalavu, seen from a neighboring hill of about 200 meters. This typical scene in the Lau group shows limestone country densely covered with forest. The island in the distance is Naitamba.

TABLE 3

Temperature Statistics of Selected Localities in Fiji

Place Province Island	Mean Temperature °F	Absolute Maximum °F and Month	Absolute Minimum °F and Month
Suva Rewa Viti Levu	77.1	98 March	55 July November
Mba Mba Viti Levu	77.7	99 December	50 July
Nandarivatu Mba Viti Levu	68.3	85 February March	45 July
Lambasa Mathuata Vanua Levu	77.8	96 February	55 July
Makongai (Island)	78.7	96 February	54 June

areas the period of compression was followed by one of tension, which resulted in normal faulting, and faulting of this type may have been primarily responsible for the breaking up of the Melanesian continent. There is some evidence which indicates that in the southeast marginal zone much of the disruption occurred during the Miocene, although it may have been initiated somewhat earlier. It has been stated that faulting in late Tertiary time was responsible for the deep water now existing between the New Hebrides and Fiji.

In considering the floristic analysis which follows, these basic geological premises may be kept in mind: first, that Fiji lies near the edge of a once-extended Melanesian continent; and, second, that its separation from other parts of the continent may not have taken place until the Tertiary, when the existing families and genera of flowering plants were presumably already largely differentiated and often widely distributed. If these premises are to receive support from botanical data, Fiji should have an indigenous flora with the following primary specifications: (1) families and genera similar to those of the parts of Melanesia lying to the west, and (2) species or subspecific units largely endemic, a situation almost inevitable if the archipelago has actually been isolated since the Tertiary by 500 miles of sea from the nearest other Melanesian land mass.

Flora

In this discussion I must limit myself to the phanerogams, or flowering plants, as statistics pertaining to other groups, such as mosses, fungi, and ferns, have not been assembled. Even the phanerogam statistics, of course, are highly provisional, as by ordinary floristic standards Fiji is inadequately known, and much work remains to be done both in the field and the herbarium. On the basis of figures now available (Table 4), there have been recorded from the group 529 adventive phanerogams, with which we are not concerned in this analysis. These are plants brought by the original inhabitants of Fiji from their ancestral homes in the west, or they are inadvertently introduced weeds, or introductions of the white man, either intentional or unintentional. Fascinating and enlightening as the study of adventives is, only the indigenous plants of a region can provide the clues to its floristic relationships. Of the 1,266 indigenous species of phanerogams thus far recorded from Fiji, we may note that 69 per cent are endemic, and I venture to suggest that both the total number of species and the percentage of endemism will rise sharply with future exploration.

First considering the indigenous but nonendemic species (Table 5), we see that nearly 50 per cent of these may be considered widespread or at least pan-Pacific; this group, of course, includes most of the common beach and lowland thicket plants. A smaller number, 25 per cent, have distributions extending from Fiji eastward in the Pacific but do not occur in Malaysia. Still smaller percentages of species which occur in Fiji have extraterritorial distributions in Malaysia, the New Hebrides, New Caledonia, and Australia.

A consideration of the geographical relationship of the endemic species (Table 6) will prove significant in inquiring into the direction of the origin of a flora. Of the 874 species of phanerogams thus far thought to be endemic to Fiji, an overwhelming proportion, more than 90 per cent, have their affinities with plants of Malaysia, and especially of New Guinea. This is not to imply that each of the 874 species is more closely allied to a Malaysian plant than to any other, for of course there is usually a high degree of interrelationship among the Fijian species of large and medium-sized genera; in such instances the relationship of the species-group has been considered for the purposes of Table 6. About 5 per cent of our species appear to be more closely related to groups that are typically New Caledonian or Australian; only about 3 per cent can be considered to belong to strictly Pacific elements. In this last group I place the species with relationships toward New Zealand and what is thought of as an Antarctic element in the Pacific.

An analysis of the phytogeographic relationships of indigenous genera (Table 7) supports the points already mentioned. Of the 445 phanerogam genera represented in Fiji by indigenous species, more than 55 per cent are typically Indo-

TABLE 4

COMPOSITION OF THE FIJIAN FLORA (PHANEROGAMS)

Adventive species (weeds, escapes, native introductions, etc.)			529	(29.5%)
Indigenous species			1,266	(70.5%)
Nonendemic	392	(31%)		
Endemic	874	(69%)		
Total number of species			1,795	

Malaysian in distribution and are represented eastward in the Pacific by comparatively few elements. More than 33 per cent of the genera occur in both the Old and the New World tropics. Comparatively small percentages of genera of Fijian plants have their centers in New Caledonia or Australia, a few are strictly Pacific or "Antarctic," and only 13 are supposedly endemic to Fiji. It should be noted that the average number of species per genus is less than three, and this in spite of several fairly large genera, like *Psychotria, Cyrtandra,* and *Ficus*. As is perhaps characteristic of insular floras, there are numerous genera represented by a single indigenous species.

TABLE 5

RELATIONSHIPS OF THE FIJIAN FLORA (PHANEROGAMS)
(Indigenous Nonendemic Species)

Widespread (pantropical or pan-Pacific)	193	(49.2%)
Also in Malaysia or Papuasia	69	(17.6%)
Limited to Fiji and New Hebrides	14	(3.6%)
Also in New Caledonia and/or Australia	18	(4.6%)
Also in Samoa, Tonga, or eastern Pacific	98	(25.0%)
Total indigenous nonendemic species	392	

Illustrative genera and species have not been mentioned in the preceding paragraphs, but those remarks should not pass entirely without documentation. Numerous Indo-Malaysian genera reach the eastern limits of their distribution in Fiji, where they are most often represented by endemic species. Table 8 lists examples of such genera, only a few of the many known. Readers acquainted with Malaysian floras will recognize here a cross section of characteristic Papuasian and Malaysian genera; that most of the listed genera are yet unknown from the New Hebrides—and many of them from the Solomons as well—will surprise no one aware of the desperately undercollected nature of those island groups. One can prophesy with reasonable accuracy what genera will eventually be found in the Solomons and New Hebrides, and

TABLE 6

RELATIONSHIPS OF THE FIJIAN FLORA (PHANEROGAMS)
(Endemic Species)

Closest relatives in:		
Malaysia or Papuasia	799	(91.4%)
New Caledonia or Australia	46	(5.3%)
Samoa, Tonga, eastern Pacific, or New Zealand	29	(3.3%)
Total endemic species	874	

even the approximate number of species that each ought to contain, if one knows sufficiently well the floras of New Guinea and Fiji. (The writer does not anticipate that he will, in his lifetime, be called upon to prove this assertion, which can be verified only by field study unlikely to materialize in the immediate future.)

Several of the genera that may be considered New Caledonian or Australian, or even African, in their primary distribution have ranges which terminate in Fiji with endemic species (Table 9). For instance, *Balanops* is known from a few species in New Caledonia and Queensland, one in the New Hebrides, and one in Fiji. *Kermadecia* is known only from New Caledonia, except for two endemic Fijian species. The myrtaceous genera *Mooria* and *Tristania* are characteristically New Caledonian, but endemic Fijian species are found growing together on the highest peak of Vanua Levu; neither genus has yet been found on Viti Levu. In passing, it might be mentioned that Vanua Levu seems in general to have a higher percentage of "New Caledonian" elements than does Viti Levu. However, since some genera of this type also occur in New Guinea and other parts of Malaysia, it is possible that New Caledonia is only a secondary center in many instances. A very curious distribution is shown by the sapindaceous *Cossignia,* which had been known from three species, two of them from the Mascarene Islands and one from New Caledonia, until a fourth was recently described from Fiji.

The so-called Antarctic element in the Fijian flora is comparatively small but nevertheless significant. A typical genus is *Collospermum* (Liliaceae), a segregate of the Palaeoantarctic genus *Astelia,* with three species in New Zealand, one in Fiji, and one in Samoa. The family Cunoniaceae (several species of *Weinmannia, Spiraeanthemum,* and *Geissois* occurring in Fiji) is perhaps to be considered an "Antarctic" group. It must not be supposed that such groups actually originated on the Antarctic continent; we mean merely that they

TABLE 7

RELATIONSHIPS OF THE FIJIAN FLORA (PHANEROGAMS)
(Genera Represented by Indigenous Species)

Occurring in both hemispheres	149	(33.5%)
Indo-Malaysian (centering in Malaysia, Papuasia, or southeastern Asia)	247	(55.5%)
Centering in New Caledonia, Australia, or Africa	24	(5.5%)
Centering in Fiji, Polynesia, or New Zealand	12	(2.7%)
Endemic to Fiji	13	(2.8%)
Genera represented by indigenous species	445	
(Average number of species per genus)	2.85	

TABLE 8

EXAMPLES OF INDO-MALAYSIAN OR WIDESPREAD GENERA WITH TERMINATING ENDEMIC SPECIES IN FIJI

(Triuridaceae)	Andruris
(Orchidaceae)	Acanthophippium
(Menispermaceae)	Pachygone
(Annonaceae)	Cyathocalyx, Desmos, Oxymitra, Xylopia
(Caesalpiniaceae)	Maniltoa, Kingiodendron
(Linaceae)	Durandea
(Rutaceae)	Wenzelia
(Euphorbiaceae)	Endospermum
(Celastraceae)	Elaeodendron
(Hippocrateaceae)	Salacia
(Sapindaceae)	Koelreuteria
(Tiliaceae)	Berrya, Microcos
(Sterculiaceae)	Firmiana, Pterocymbium
(Dilleniaceae)	Wormia
(Saurauiaceae)	Saurauia
(Ochnaceae)	Brackenridgea
(Begoniaceae)	Begonia
(Thymelaeaceae)	Gonystylus
(Araliaceae)	Plerandra
(Loganiaceae)	Couthovia
(Rubiaceae)	Airosperma, Amaracarpus, Mastixiodendron

(or their immediate relatives) now have a bi- or tricentric distribution in the Southern Hemisphere, a distribution most logically explained by assuming a warm-period migration across, or along the fringes of, Antarctica. Only after exhaustive study can a monographer even tentatively state the probable place of origin of a group of plants. Since many of the allegedly "Antarctic" groups may be Australasian or even Malaysian in ultimate origin, discussions of their phytogeographic significance should perhaps be very guarded.

The genera of phanerogams endemic to Fiji are listed in Table 10. The word endemic must be used cautiously here, as only 25 or 50 years ago such a list would have been conspicuously longer than the one here presented. As botanical exploration in New Guinea and the Solomons continues, and as the plants of that region are studied in connection with Pacific floras, we see the list of supposed endemic genera in Fiji gradually dwindle. At present I find recorded only 13 such genera of phanerogams, and it must be admitted that some of them are very much suspect, being separable from close Indo-Malaysian relatives by technical characters of questionable import. One may even wonder whether the recently described *Degeneria* is a true endemic. I think it likely that this remarkable genus will yet turn up in the New Hebrides, the Solomons, or even in New Guinea.

In consideration of the above statistical analysis of the known phanerogam flora of Fiji, we clearly observe that these data support the hypothesis most favored by geologists. The primary relationship of the flora is with the Indo-Malaysian, and especially the Papuasian, region. The small (and questionable) degree of generic endemism and the very high degree of specific endemism indicate that Fiji lost its land contact with the rest of the Melanesian continent at a period when genera were already well established but when species were not well defined. Genetic interchange between parts of the populations, below the level of genus, was probably not seriously impeded by geographic barriers until the final breakup of the continent. After this date, the portions of genera left in Fiji, their genetic possibilities comparatively limited, tended to diverge from the populations similarly stranded in other archipelagos. That this date was during the Tertiary botanists may accept, but to qualify it further will take studies on the rate of evolution which seem to belong to future researches.

One may assume, I think, that the last land connections to be sundered in this general region were those joining Fiji with the New Hebrides, the Solomons, and New Guinea. Botanical evidence would indicate that the land connections between Fiji and New Caledonia were disturbed much earlier (if, indeed, they ever were direct rather than circuitous, as for instance by way of insular interpolations between New Caledonia and the New Hebrides). The floristic relationships between Fiji and New Zealand, and between Fiji and Polynesia proper, are by comparison so tenuous that one cannot hypothecate direct land connections.

TABLE 9

EXAMPLES OF GENERA CENTERING IN NEW CALEDONIA, AUSTRALIA, OR AFRICA WITH TERMINATING ENDEMIC SPECIES IN FIJI

(Podocarpaceae)	Acmopyle
(Balanopsidaceae)	Balanops
(Proteaceae)	Kermadecia
(Euphorbiaceae)	Buraeavia, Cleistanthus
(Sapindaceae)	Cossignia
(Violaceae)	Agatea
(Myrtaceae)	Mooria, Tristania
(Epacridaceae)	Leucopogon
(Myrsinaceae)	Tapeinosperma

The problem of the origin of the Polynesian floras is more controversial than the problem here discussed. The strictly oceanic groups, from Samoa to Hawaii, probably did not receive their plant populations by so simple an overland route as Fiji.

TABLE 10

GENERA OF PHANEROGAMS ENDEMIC TO FIJI

(Palmae)	Goniocladus, Goniosperma, Taveunia, Vitiphoenix
(Degeneriaceae)	Degeneria
(Simaroubaceae)	Amaroria
(Sterculiaceae)	Pimia
(Vacciniaceae)	Paphia
(Rubiaceae)	Readea, Gillespiea, Sukunia, Hedstromia, Eumorphanthus

Amorphophallus campanulatus is a wide-ranging species, occurring from the Asiatic mainland throughout Malaysia into the Pacific. The genus, although very rare in Fiji, is a typical Indo-Malaysian element of the flora.

Whether these archipelagos were populated exclusively by plant waifs, borne in the arms of rare and violent atmospheric disturbances, or whether routes of migration now submerged (and generally denied by geologists) made them accessible to land plants is a question beyond the writer's ability to discuss.

It is fashionable, in certain circles, to decry biological taxonomy as an irrelevant branch of science. The mere naming of organisms and the assembling of statistics pertaining to them would perhaps, in itself, be a comparatively unproductive pursuit. But few taxonomists believe this to be the goal of their work. Extensive collections of herbarium specimens, even in little-known tropical countries, could perhaps not be justified were their scientific usefulness terminated once they were identified. But, on the contrary, it is at this point that large herbarium collections begin to assume their most significant functions—to further our knowledge of phytogeography, to supplement a purely geological knowledge of earth history, and to indicate trends of phylogeny. When the floras of all the Pacific archipelagos are so well known that they can be statistically analyzed, we shall know significantly more about the history of earth movements in that region, even if the final words must be left for geological research.

As to studies of plant phylogeny, taxonomists have always been fascinated by speculation as to the origin of the angiosperms, the major group of land plants now extant. Since the time of A. L. de Jussieu, in the late eighteenth century, there has been a prevalent belief among students of phylogeny that the most primitive extant angiosperms are to be found in or near the large order Ranales. It is not possible here to discuss the ranalian characteristics that lead us to consider the order comparatively primitive—by which is meant less changed from a hypothetical angiosperm ancestry than the rest of the vast phylum is changed—but many recent technical studies from taxonomic, morphological, and anatomical viewpoints bear out that assumption. It is interesting to note that most of the phylogenists who, until fairly recent years, speculated along these lines were well acquainted only with the plants of the Northern Hemisphere, among which they sought in vain for a primitive angiosperm. It now appears that the angiosperm families which exhibit, to varying degrees, combinations of primitive morphological

Taetsia fruticosa is seen everywhere in the undergrowth of the Fijian montane forest.

features are basically Indo-Malaysian groups. A list of such families must include the Magnoliaceae and Annonaceae, familiar to students of north-temperate floras, but also less well known ones like the Winteraceae, Trochodendraceae, Tetracentraceae, Schisandraceae, Illiciaceae, Monimiaceae, Amborellaceae, Himantandraceae, Degeneriaceae, and others.

Fiji provides only one of these critical families, the endemic Degeneriaceae, but the archipelago lies on the edge of the region which seems most likely to produce significant clues in a study of angiosperm phylogeny. To quote pertinently from I. W. Bailey:

> It is the living floras of northern Australia, New Guinea, New Caledonia, and Fiji and adjacent regions northward to southern China that have yielded and are continuing to yield the richest crop of missing links in the chains of angiospermic phylogenies. For example, of the nine known genera of primitive vesselless dicotyledons, five occur on New Caledonia and three are endemic on that island. Only a beginning has been made in the exploration of many of these floras and a continuous flow of significant new plants may be anticipated for some time to come as more and more complete collections are assembled. Furthermore, these living floras of southern latitudes have already yielded more structurally primitive dicotyledons than have all of the known fossil floras of northern latitudes.

In Lambasa, a little town on the north coast of Vanua Levu, there is a small hotel which boasts, on its letterheads, of being "the first hotel on which the sun rises." It is indeed true that Fiji and Tonga are the first tropical lands to greet each new day, thanks to a bend in the international date line. That the sun should rise first upon an area of such potential significance in the study of plant phylogeny suggests an amusing, if wholly unscientific, symbolism.

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The work that we have indicated implies a great amount of labor, and Dr. Gray is essentially a worker. No mechanic goes to his daily task more faithfully or continues at it with more assiduity than he. Very few, who are not familiar with the laboratories and studios of scientific men, have any idea of the amount of labor performed in them. Their work is by the many looked upon as a sort of half play, not to be compared, in its demand upon the physical and mental resources, with the daily task of the book-keeper or cashier. There are not many who work harder than Dr. Gray, but, when work is over, few more keenly enjoy the relaxation. . . . It is supposed by many that a student's life diminishes bodily vigor. We can name several striking illustrations to the contrary, and eminent among them is the subject of our sketch. We have not tried a walk with him for several years, but we venture to say that few young men of twenty could take an afternoon's tramp with him and not feel a sense of relief when the excursion was ended. . . . Outside of the domain of botany, Prof. Gray's contributions to literature are not a few. . . . Some of his reviews are remarkable specimens of acute criticism, in which the subject could forget the sharpness with which he was flayed, in admiration at the dexterity of the operator.

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Of Science, Its History, and the Teaching Thereof

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THERE has come into existence, by this midpoint in our century, a substantial and rapidly expanding literature concerning itself at various levels and from different angles with the general question of the significance of scientific development and the impact of this development upon our time, our society, and its fate.

This phenomenon is simply a reflection of the obviously large, and ever growing larger, role that science has been playing in all aspects of our activities. The sensational impulse given by political and social discord to the perfection of instruments of destruction—by-product of, but closely related to, some of the more abstruse developments in theoretical physics—has brought the ordinary citizen to an acute and immediate awareness of the possible consequences for him of what goes on in the quiet of a laboratory. Even physical scientists have in some cases been jarred into an unwonted feeling of social consciousness and responsibility. But for all the awesome possibilities of modern explosives—those so far tested and their improved versions in course of realization—the atomic bomb was but an incidental manifestation of a process which has been under way for a considerable span of time.

Dangerous as it is merely to extrapolate from the past, it is nevertheless useful to recall that many before 1914 drew confidence from the very effectiveness of the then existing engines of destruction: civilized man would not go to the length of wrecking his society and his culture. The argument is still heard, though its echoes carry ever-feebler conviction. It is indeed the year 1914 rather than that of Hiroshima which marks the turning point in our time, for by now we can see that, whatever the future may hold in store, it was the first world war that ushered in the era of confused transition in the midst of which we are floundering. To be sure, questionings of the direction in which the world was moving can be found in pre-1914 literature, but the prevailing atmosphere of that era was rather one of optimism, in bolstering which the record of the beneficial achievements of science constituted one of the strongest arguments. After a brief interlude of hope during the middle twenties, once the fallacious bases of that hope that the world was again set on the path of continued progress had been exposed, the Western world, at least, has plunged into a deepening gloom of worried questioning over its future. Even America, prime example of successful modernity, although more optimistic and hopeful than the battered European battleground, no longer enjoys the unmixed confidence in the future characteristic of the climate of its astounding growth.*

Curiously enough, it may be said without exag-

* What goes on behind the Iron Curtain is (for us) shrouded in a fog of uncertainty and confusing reports. But there seems little reason to doubt that, however unfortunate, inhuman, and dangerous from our point of view, the novel experiment of Communism has not exhausted its original component of optimistic vigor, while the West does not possess it; hence the contrasting climates that one hears reported from, say, Poland and France. This is perhaps not too surprising if one considers that the West is mainly looking to a past that it wishes to prolong (though possibly modify), whereas the East is rather looking to a land of future promise. The validity of these estimates is less relevant than the fact of their prevalence.

geration that the very development of scientific knowledge and the growing impact of technology—an activity distinct from, but closely related to, the scientific—are at the root of the diverse climates of Western thought since, as well as before, the first world war. There is no need to expatiate on the role of inventions in the reshaping of our lives and our economies: the relatively recent introduction into common usage in history texts of the phrase "Industrial Revolution" was but the belated recognition of a phenomenon that received its initial impulse nearly two hundred years ago in Britain. Invention and scientific development are distinct activities; but with the passage of time, the growing systematization of knowledge, and the discovery of an increasing number of broad general laws of nature, the tendency has been for technological development to become likewise ever more systematized, and increasingly dependent on organized scientific investigation, even though the field of accidental discovery, whether in science or in technology, is by no means closed. The growth of modern chemistry is a case in point. It has become a common practice for industry to maintain its own research laboratories and to consider the subsidizing of even the most abstract research a sound long-term investment.

What it all adds up to is the new and vast importance which the scientist and the technician have assumed in the shaping of our affairs, and the complexity of our industrial civilization depending for its successful operation—perhaps even survival—upon the proper functioning of the delicate adjustments of our industrial economy, in contrast with the days of a simpler and more stable agrarian society. There was no need of Marx to convince us of the importance of economics, better named political economy; in a sense we are all Marxists nowadays. Economics, indeed, has come to dominate our activities to an overwhelming (unfortunate, some would say) degree: one need only look at the amount of space devoted in our serious press to labor problems, price relationships, and exchange difficulties, in order to realize the fact. Or consider the treaties that follow our wars by comparison with, say, the arrangements of the Congress of Vienna: Vienna was, relatively speaking, and could afford to be, innocent of economics: the bulk of a modern treaty is apt to deal with matters economic. Our daily politics itself has a large economic content. What this reflects is the changed nature of the modern world; or, as it has been put, Marxism (meaning the economic interpretation of history) is truer today than it used to be.

All this is, in a sense, belaboring the obvious. But its deeper significance may be worth pondering, for it means that the citizen of a modern state finds himself called upon to pass judgment on matters where he has no competence and to make decisions in the lack of proper understanding: as a consequence, his response is likely to be based on prejudice, emotion, or at best broad general principles whose applicability may or may not be valid in the circumstances. This, of course, is in a democratic state where the citizen has freedom of choice and a say in matters governmental. It is indeed essential not to lose sight of the fact that our twentieth-century totalitarianisms, whether red, black, or brown, are in large measure a response to economic problems and an attempted short cut to their solution: outwardly and superficially, modern man can most easily be dealt with and organized if considered primarily in the light of an economic unit. And that, incidentally, is one reason why the various brands of totalitarianism, whatever their variegated ideological content from other sources, present such a large area of agreement in practice.

There are many who feel that the economic forces unleashed in the modern world will ineluctably drive us into some form of totalitarianism, that freedom and organization will prove irreconcilable antagonists, and that since we must have organization (in order at the very least to exist and survive) freedom will have to be jettisoned. However unattractive, this reading of the modern world is not one to be lightly dismissed. But those who, for whatever reasons, would not surrender the value of freedom must face squarely such problems as, for instance, how to produce an intelligent and competent electorate. Merely to quote Jefferson or the Declaration of the Rights of Man will not serve us very far unless we can rejuvenate such lofty pronouncements in the context of our present-day society. Jefferson, for that matter, entertained considerable qualms about the prospects of an industrial society. But, for good or evil, an industrial society, closely related to a thriving science, we do now have.

The challenge here indicated resolves itself for the longer term and in a fundamental sense into a problem of education. In view of the highly technical character of our civilization, behind which phenomenon lies that of scientific growth, what should be the content of an adequate education, and, as a corollary, how can such an education be provided?

Immediately, when facing this problem, we meet the condition that education in our day is mass

education, and that, nowhere perhaps more than in America, considerable confusion has come to surround the issue of education in a democracy. Like it or not, the fundamental inequality of man has to be recognized and, for the purposes of this discussion, will be taken as "clear and self-evident truth." It will be assumed in addition that: (1) a democracy need not deny itself in recognizing this fact so long as it ensures equality of opportunity to its members, and (2) a democracy, like any other form of society, especially a complex modern industrial society, cannot successfully operate save under the guidance of an elite. Having made these assumptions, I wish to consider more particularly the issue of the training of such an elite—or leadership, if the overtones recently attached to the word elite should make the use of it appear obnoxious.

Were it not for the all-pervading political stresses of the day which color all our thinking, the problem might perhaps better be approached from a somewhat different, more philosophical angle. Leaving politics aside, one might put the question: What, in the modern world, constitutes the proper foundation of a well-rounded education viewed as an end in itself? But the difference in emphasis would not alter the basic considerations, for it will appear at once that the proper training for leadership must be founded on an adequate understanding of the world that is.

Here again we run at once into the issue of the role of science in the modern world, whether one take it at the level of the shaping of our society, or at that of understanding the universe around us —a universe of which our own world in the limited sense of this planet, its dwellers, their nature, and their relations are a small but, naturally to most of us, inordinately important part.

Traditionally, the proper basis for an education aimed at producing well-rounded human beings—and, incidentally, also competent political leaders—has been considered to be a primarily classical or literary training. Such has certainly been, almost to this very day, the normal background of British political leaders. Indeed, if one had to make a choice between either a purely classical-literary training and an exclusively scientific one, there would be little reason not to opt for the former: the humanities, as the very name suggests, make for a broader and sounder *human* understanding than the sciences. The present state of development of psychology and related disciplines, which perhaps should still be labeled pre- or pseudo-scientific, precludes their serving as an adequate substitute, whatever their role may come to be in future. But, unquestionably, a primarily classical education leaves out of its province too much that has become of vital importance in our time.

The youth and novelty of the scientific process, as well as the uniqueness of it, must be stressed at this point. This statement may warrant a little elaboration. It is usually recognized that the ancient Greeks were the first to evolve something that may be genuinely called science. Much work has already been done which has traced the roots of that development to what was at the time of its occurrence ancient times—Egypt and Mesopotamia of a great many centuries before the Greeks appeared upon the stage of history. These researches do not detract from the peculiar nature and quality of the Greek achievement, which may truly be called unprecedented. Note in passing that the Egyptian start, for instance, although much older than the Greek, seems to have progressed rapidly for a brief time, then to have crystallized and failed to continue its growth.

The Greek phenomenon, though far more impressive and systematic, was also relatively short-lived. Two things seem clear in connection with it. It took some fifteen hundred years before the process was resumed, during which interval the ancient world was to disintegrate before the process of rebuilding could start. But, even more significant perhaps, even before disintegration set in, the process seems to have become largely arrested: the Romans did not take to science, good organizers and engineers though they were. In an excellent recent book, Professor Butterfield has put it aptly: "There does not seem to be any sign that the ancient world, before its heritage had been dispersed, was moving towards anything like the scientific revolution."† The shortcomings of the ancients may have been the result of their failure, despite such names as Archimedes and Galen, to develop the experimental method: their crowning achievement lies in pure mathematics.

The so-called Middle Ages were, from the standpoint of scientific growth, truly dark. The decline of the West brought it to a much lower condition than that reached by the East, whether Byzantine or Moslem. But Byzantium, closer to Greece and in physical possession of the Greek lore though it was, developed a spirit wholly different from, not to say antithetic to, that of ancient Greece. Possibly the Judaeo-Christian phenomenon distorted the Greek love of logic into the familiar "Byzantine" form: legalistic sophistry may be regarded as a point of contact.

† H. Butterfield. *The Origins of Modern Science, 1300–1800*. London: 163, (1949).

It was left to the more vigorous Arabs to instill the fresh air of their native desert home into a decadent and ossified East and to become the agents of a new synthesis. The story of the golden age of Islam, by which time it was characterized by the sophisticated catholicity of its tolerant taste and outlook, is a fascinating one. But what is equally relevant in this context is that the Arabs—or rather the wide variety of peoples whom they brought under their control and who came to pass under their name—were not so much innovators as collectors, organizers, synthesizers, and, most important, carriers of the contributions of other times and peoples. This is not to deny or minimize the crucial importance of their role, or to ignore the fact that they made some valuable contributions of their own; but it remains largely true that the initiation of the "scientific revolution" was not of their own making.

Nevertheless, to this making they contributed mightily, and the story of the West would certainly have been different but for what it learned in Spain, in Sicily, and in Syria. But the Arabic contribution was, to repeat, mainly in the form of a transfer of the ancient learning and wisdom, in the field of science at least. The "scientific revolution" was destined to be the exclusive appanage of the West, a West taken geographically in the narrowest sense: a region bounded by the Atlantic (including the British Isles), the Pyrenees, and, roughly, the Trieste-Danzig line of our time.

The phrase "scientific revolution," of necessity somewhat vague, perhaps should be more closely defined. It is used here in preference to the too-controversial "scientific spirit" or "scientific method" and, for purposes of this discussion, may be taken in the sense of the consequences of the application of the rational faculty, through the analytical method, to the raw material of observation and controlled experiment, from which endeavor emerges the synthetic formulation of natural law. This law, mathematical in its purest form, is the expression of the human understanding of the universe. Equally important, the process is embedded in a secular atmosphere; although dedicated to the search for truth, it stands in sharp contrast to the approach of "revealed" truth. To quote Butterfield again: "The very strength of our conviction that ours was a Graeco-Roman civilization . . . helped to conceal the radical nature of the changes that had taken place and the colossal possibilities that lay in the seeds sown by the seventeenth century" (*Ibid.*, 173–4). Professor Butterfield does not ignore the much earlier beginning of the process, the title of his book itself bearing the chronological qualification 1300–1800, and perhaps one might quarrel with his use of the word "seeds." For the Newtonian synthesis, if it was a seed in that from it there stemmed further developments, may also be regarded as a prime and full-grown sample of what science at its purest and best is. But placing the scientific revolution in the seventeenth century seems apt, for Newton's may be said to have been the first complete illustration of the new phenomenon: the power and beauty of that first accomplishment, prepared as it was by the germinal work of some earlier centuries, being all the more impressive from its being the first fully elaborated synthesis.

It is therefore not surprising that Newton's accomplishment should have been so potent an influence on the century that followed him; but it is no less revealing that this work should have been done essentially outside the formally established institutions that monopolized instruction in his day. Before the universities could assume the function associated with them at present, they had to be rejuvenated by their eventual absorption of, or—perhaps better—conquest by, the scientific societies.

It may not be amiss to recall the well-known fact that Voltaire, as much as any one individual, was the popularizer of Newton. Voltaire was essentially a literary man, not a scientist in the technical sense; but the fact that he could be the agent (if the best known, he is but one among many of that ilk) that spread the Newtonian influence points to a significant difference between the eighteenth century and the succeeding era. Broadly speaking, it was still possible in the eighteenth century for the generally educated man to encompass the knowledge of his day. But from the beginning of the following century (the division is, of course, too rough but will serve) this state of affairs becomes increasingly rare, not to say impossible. It is an obvious platitude, often commented upon, that in our time, the accumulation and complexity of knowledge compel even those who devote their entire energy to the scientific endeavor to circumscribe their activity within the narrow confines of some particular branch of one field. Looked at in a somewhat different way, science has been encroaching ever more on the traditional preserve of the philosopher. And another aspect of the changed situation is that insofar as we have philosophers capable of taking into account a substantial segment, at least, of existing scientific knowledge—as indeed philosophy should—such individuals are apt to have begun their careers with a technical scientific training: the names of Bertrand Russell and Alfred N. Whitehead illustrate the point. This could hardly be otherwise, for the reverse process of beginning to acquire scientific train-

ing and knowledge after a training in philosohy offers well-nigh insurmountable difficulties.

This brings us back to the question previously touched upon, of education in and for the present world. At this point, it is essential to make some basic distinctions. Is it possible for the modern educated man to have an adequate knowledge of science? That it is ideally desirable that such should be the case I am taking for granted. But how much knowledge of science can in practice be expected to be squeezed into a general curriculum? Could the problem be solved by finding some device for conveying an understanding of what the scientific process is, as distinct from the study of any one individual science?

There has been much recent discussion of these problems. To a degree, and as was inevitable, science instruction has penetrated the most elementary levels of education; the reason for the debate lies in the general recognition that what has been done so far is either inadequate or unsatisfactory. But there is even more to the problem, which shows the difficulty of its solution. It might at first thought be expected that the question of an adequate scientific education would automatically be solved for the student specializing in some particular science. But that is far from being the case. The very degree of specialization entailed militates against breadth of outlook, with the result that the student of science is apt to be more insensitive than his literary counterpart to the complex totality of the world around him.

This may seem paradoxical in view of the overwhelmingly important role of science in shaping our modern world, but it can be understood easily enough. The literary disciplines, the humanities, from their very nature stress the historic process; they make for perspective and balance: within historic times, it is reasonable to regard human nature as a constant. But the case of science, as pointed out in the foregoing brief sketch, is other. Science as it has come to be is unique and novel, with roots indeed, but no real precedent, in the past. Hitherto confined in the main to a narrow section of the West, it is in process of spreading, but has meantime substantially remolded the entire planet. For purposes of technical or specific scientific advancement, the historic approach usually seems to be, and in fact often is, irrelevant. Plato, Spinoza, and Kant are our contemporaries in a way that Galileo and Newton are not. The present-day aspiring astronomer does not, and need not, read the original work of Ptolemy, let alone the mass of astrological lore. Quite properly, and at a great saving of time and effort, he will seek to bring himself up to the present stage of astronomical knowledge by perusing the most up-to-date texts and treatises, and this will lead him to the stage where he can bring himself abreast of current activity in the suitable technical journals. Granted the proper mental equipment, he may in this wise become a thoroughly competent astronomer and contribute to the further advancement of his chosen activity. This state of affairs is merely a consequence of the essential and peculiar nature of science.

For the sake of clarity, a word should perhaps be said about a common confusion. It will appear from the foregoing that I have used the term "science" in a narrow sense. I have done this deliberately and because I think that the use of the term has been loosely and regrettably extended. I should much prefer to eschew the phrase "social sciences;" not that the disciplines under this head are not valid and vital, but because they constitute radically different activities, and the phrase represents at best an expression of hope in their future possibilities, and at worst a premature claim to be what they are not. Even historians have put forward the claim to being scientific: what is meant is that history has learned to make use of certain techniques comparable to those of the laboratory. Scholarship is indispensable, to be sure, and fully worthy of respect. But scholarship is essentially a tool. In its present state of development—and whether this can be exceeded is questionable—history at its best, a best which can be very good indeed, is reflective consideration of the record of man. And so historians continue to differ in a way that physicists do not. Having made this clear, it must be recognized that if we take, say, mathematics and history as typifying opposite extremes, there is between them a whole gradation among intellectual disciplines, which could be classified on the basis of the degree of precision attained or possible of attainment in the results of their accomplishments.

What has just been said will serve to explain, though not justify, the fact that the student of science often harbors an attitude of condescension toward the looser disciplines of the social sciences. At the same time, it is not rare to find among the better scientists a marked interest in the philosophical implications of their work, the history of its development, and even plain history unqualified. This reflects the fact that, whereas anyone can read history and few are equipped to understand technical scientific papers, history is in a sense a maturer discipline than science: outstanding achievements in science are not unusual at a very early age; the training of a good historian is apt to take

much longer, however brilliant the initial endowment, for intelligence by itself is no substitute for the ballast that years and experience alone can provide.

We thus come to a synthesis of which the history of science is the expression. This particular form of activity is currently thriving and is attracting an increasing following. George Sarton has done valuable pioneer work in this field and may be said to have given the movement its real start, in this country at least. The organization of a History of Science Society and the recognition given to this field by our universities are a measure of the merited success of his endeavors. But the history of science is a very special sort of affair. It may be worth considering for a moment two obviously related yet distinct aspects of this activity: as an end in itself, or a self-contained discipline; and as a factor in the general scheme of education.

Any one particular science has its history, and there have been extant for some time specialized histories of mathematics, of physics, of biology, or even of particular branches of these fields. Such histories have been written by technicians in their respective fields; indeed it could hardly have been otherwise. They are apt to be of limited scope and interest, and their accessibility to those outside the particular field with which they deal decreases in proportion to the proximity of that field to the disciplines that go under the head of pure or exact sciences: the nonmathematician can go a much shorter distance (meaningful distance, that is) in a history of mathematics than the nonbiologist in a history of biology.

We run at this point into a difficulty for which there seems to be no available solution. If we are to discuss in a serious way the significance of Newton in the development of science, the term "calculus" must have concrete meaning, meaning which does not seem accessible save by actual and direct acquaintance with that particular branch of mathematics. It is easy enough to talk in general terms about the Newtonian synthesis, the Newtonian world machine, and the influence of these concepts on eighteenth-century thought and even politics. Such considerations are legitimate and valuable, but we are dealing then with the generalized history of ideas, and my contention is that this is not the same thing as history of science—not unless we indulge in confusion of language and thought. To be sure, it would be most valuable for the student of mathematics or physics to be exposed to a solid course in the history of ideas. Such courses have been in existence for a long time, and they have traditionally, and rightly, been chiefly the preserve of philosophers and historians.

As stated before, the case of the exact or pure sciences presents the greatest difficulty. The more descriptive natural sciences are decidedly more manageable. An illustration of this state of affairs may be found in Nordenskiöld's *History of Biology* which, in addition to being what its title announces, situates the development of biology in a broad philosophical context. Compare this work with, for example, the existing histories of mathematics. Not that a similar job could not be done in the latter case, although it would immediately be confronted with the twin difficulties inherent in the nature of the subject and in its relatively greater aloofness from the other concerns of mankind.

James B. Conant, of Harvard, himself a scientist of note, has devoted much thought to the question of the place of science in the general scheme of modern education. His solution, presented in a series of lectures under the title *On Understanding Science,* is not to try to give the student a superficial smattering of specific scientific knowledge but to tackle the much more fundamental problem of conveying an understanding of the essential nature of the scientific process. In view of some of the basic difficulties, inherent in the nature of science itself, this may perhaps be the best that can be hoped for. According to President Conant, the way to achieve this understanding is by means of the historical approach, by following from their origin through the growth to their successful establishment certain adequately chosen specific concepts. In the course of such a study, what he calls the "Tactics and Strategy of Science" could be analyzed and understood. Quite apart from the specific illustrations chosen by Dr. Conant, his suggestion seems a promising approach to an effective solution of the problem of how to divest science of its present-day magic connotations and to bring its operation into the full light of rational understanding. It is to be hoped that the experiment of a course in the Tactics and Strategy of Science will be tried. If done properly, it could not help but prove at the very least a stimulating venture.

It is well to be clear, however, that such an undertaking is not the same thing as the history of science. Nor does Conant claim that it is, being concerned primarily with filling the scientific gap, in the sense of conveying an "understanding of the meaning" of science, in the broad scheme of modern education. Granting that the historical approach to the understanding of science can be a fruitful one, the history of science as such will remain a related but distinct discipline. That such

a subject should be cultivated is certainly desirable—that, in fact, is being done to an increasing degree—but there should be no illusions on the score that the activity will remain a highly specialized one that will have a very limited appeal.

Despite the growing attraction of the modern student to the sciences, the student of science is in general uninterested in the historical approach, and the student of the humanities lacks competence to delve with significance into the scientific prospect. At the risk of seeming old-fashioned, I think it might be worth considering whether the best way for all to overcome this admittedly unfortunate barrier might not be through the restoration of the old-time requirement of a general philosophy course. Might not such a course, when it comes to the modern period, incorporate some sections along the lines suggested by Conant? General philosophy, with its largely historical treatment, would be an excellent discipline for the science student. Of the much-discussed possibility, in some instances already tried, of a so-called General Science or Science Survey course, I must confess to taking a decidedly pessimistic view. To be sure, if given by the right person, it can be interesting, valuable, and stimulating. But General Science, above the very elementary level, stands in danger of falling between too many stools: if given by a scientist qualified in some particular field, it is likely to become too narrow a course in that field, possibly overflowing so some extent into immediately related ones; if given by someone with "general" competence, which may not be very different from general incompetence, the result is apt to be a superficiality—either through becoming a catalogue of "scientific" facts, or generalized "talk" devoid of substance—that will be tantamount to defeating the essential purpose of the undertaking; if organized as a "vaudeville" type of course, perhaps the shortcomings of such an enterprise at this level (chiefly the lack of integration owing to the absence of centralized responsibility) need not be elaborated.

It has been indicated that, for the prospective specialized student of science, there is much to be said for the general philosophy course previously mentioned. This might profitably be followed by the requirement of a course in the history of the particular science in which the student wishes to specialize. Such a course should, in fact could only, be given by a physicist, chemist, biologist, or whatever the case might be. It would not have to avoid technical considerations and would represent the history of science at the best and highest level, without apologies, limitations, or qualifications.

This kind of course, because of its highly specialized nature and stringent requirements, could obviously have meaning for a very limited circle only. And this aspect of the matter points to one of the basic difficulties that confront the history of science as a discipline. For the history of science is a radically different thing from any other kind of history. Professor Sarton has pointed out that the generalized historian may with relative ease penetrate any period or aspect of history with which he happens to be unfamiliar; but that this no longer holds as soon as we deal with science. One consequence of this situation has been that, aside from certain treatments of their particular field by individual scientists, the history of science has concerned itself to a great extent with antiquity and the Middle Ages. No one more than Sarton has given a greater impetus to the organized study of the history of science. Logically enough, he has started with the beginnings of scientific activity, interpreting the phrase in the broadest possible sense. He would be the last one to entertain the ludicrous notion that his undertaking could be carried to completion by any one individual. Indeed, considering the standards of his scholarship, one can only admire the industry which has enabled him to carry the task as far as he has. His is a contribution of the first magnitude toward the ultimate aim of integration of which Butterfield's book represents an essay. It is to be hoped likewise that Professor Sarton's proposed Institute for the History of Science and Civilization to carry out in organized and systematic fashion the work that he has initiated may, in some form or other, come into existence.‡ Much could be expected from such an organization.

The fact remains, nevertheless, that the bulk of the work so far done deals essentially with prescience. To repeat again, such work is both legitimate and necessary and by no means to be disparaged. But I should go so far as to say that much of it contributes little to a direct and real "understanding" of science, and may in fact be carried out with little such understanding. It has been known to happen that a technical scientist called in to attend the defense of a doctoral dissertation in the field of the history of science has acquiesced with polite wonderment in the favorable verdict despite what appeared to him the fundamental lack of knowledge, let alone understanding, of his particular activity evinced by the candidate. This does not mean either that the scientist's estimate was incorrect or that the dissertation in question was not a sound piece of scholarship—within certain

‡ For a fuller discussion of this suggestion, see Sarton's own book: *The Life of Science*. New York: (1948).

limits. It is rather a measure of the magnitude of the gap that separates the two disciplines of history and science and of the difficulties that will confront the historian of science in increasing degree as he attempts to deal with the highly technical aspects of the current period.

Around this difficulty I see no short cut. If the foregoing be a sound estimate of the situation, if one grant the premise that science is basically a novel, unique, and unprecedented phenomenon of very recent occurrence, this does not detract from the validity of the claim that the historical approach is not subject to the limitations of the narrowly scientific. In the light of the difficulties which have been indicated, perhaps some conclusions may be ventured.

At the risk of seeming unorthodox and iconoclastic, and despite all that has been said about the nefarious effects of overdepartmentalization and the stress on the reverse need for breaking down the barriers between diverse disciplines, I should say that this is a case where the first requirement is to clarify distinctions. The history of science can and should prove a marvelous instrument of integration, and it is to be hoped that contacts between historians of science and ordinary historians on the one hand and scientists on the other will continue cordial and become intensified; their joint meetings could prove eminently interesting and fruitful. But we should not be misled by the use of the word history. It would probably be best for all concerned, and most advantageous to historians of science, if the latter were free, in the departmental and organizational sense, of formal connection with historians. It is of course necessary that the historian of science be properly grounded, and it may be assumed that he will be so grounded, in history and historic discipline; the greater difficulty and more likely deficiency lie in his scientific knowledge and background. To put it bluntly perhaps, yet I believe soundly, it is possible for scientists to have an appreciation and understanding of the significance of historic development, even though too many may be blind to it; but, save for odd individual exceptions, general historians do not have an understanding of science and are therefore not competent judges of the soundness of historic work in that field at the very point where its significance becomes crucial, namely, in the modern, the only truly scientific, period. There is undoubtedly danger of confusion and of the history of science falling between two stools in the event that scientists should take the position of being at best indifferent, at worst antagonistic, to an activity which, because of its potentialities, should instead command their interest, cooperation, and respect. Scientists, for their part, have an important contribution to make in the form of divesting themselves of the not infrequently narrow outlook, even attitude of superiority, that derives from the esoteric exclusiveness of their guild: outside their specialized activities they are indeed, as a group, no more perceptive than their more literary colleagues. But their standards, unlike literary and artistic standards—and history is more art than science—are at once precise and exacting. Insofar as historians may wish to penetrate the scientific domain, it is up to them to meet the level of those standards.

This leads to another consideration. How is the historian of science to meet the suggested requirements? Obviously, he does not have at his disposal several lifetimes in which to prepare himself for his elected task by penetrating the various fields of science. The limitations of the human frame and mind cannot be ignored. But at the very least he must have an *understanding* of what science is. This cannot be obtained by reading literary disquisitions on the general subject of science, but only by studying science, some one science at least, at firsthand. To be concrete, let me say that the prospective historian of science should have at least the competence that might be obtained by two years of graduate work at one of the better universities by the specialized student of science. This is what the general historian has not, cannot be expected to have, and does not need to have. And that is why, as a consequence, he is not likely to be a qualified judge of scientific history.

It may be pointed out that the suggested requirement is stringent and also that the aspiring historian of science may encounter difficulty in finding proper interest in and guidance for his chosen work: he may find himself caught between the Charybdis of inadequate advice from sympathetic historians and the Scylla of neglect on the part of uninterested scientists. This is undoubtedly a risk and constitutes one of the chief arguments for the earlier-advocated separation of his activity. It may as well be recognized from the start that the history of science is a highly specialized undertaking. As such, and for that reason, there is no need that the discipline be pursued in every center of learning, but like other highly specialized activities it may best prosper if allowed to flourish in a few chosen centers that will elect to give it full recognition and scope; in addition to which, the more specialized aspects of the history of science could be dealt with at any time and place *within* the suitable scientific departments.

A final point may be considered. What, if any, is the place of the history of science at the college level? For the prospective student of science, a possible solution has been indicated earlier in this discussion. For others, one runs at once into the difficulty of very disparate (such as it is) and on the whole inadequate scientific background. In addition, although some students outside of the prospective scientists will be interested in the history of science, their number of necessity will be small. If we do not fall back on the suggestion of a general course in philosophy, perhaps the best solution—a closely related one—may be found in the treatment of the history of science as a subdivision of the history of ideas. In this case, the most likely candidates for the presentation of the subject are likely to be found neither among the scientists—although this might happen in individual cases—nor among general historians, but in the ranks of the philosophers. Not *any* philosopher, to be sure, but philosophers are close to logicians and this brings us into a realm with distinct possibilities.

The considerations presented here may be open to the criticism that they raise more questions than they answer. Some of them, in addition, may appear highly controversial. Very likely they are, and the justification for them lies in the feeling that the history of science is a relatively new field for which there is marked necessity, whether one have in mind primarily the philosophical approach of pure understanding for its own sake, or the more practical and immediate concern with the sorry condition of our political affairs. The opportunities of the endeavor may be said to be matched by the difficulties that surround it. The first requirement of its success lies in a clear awareness of these difficulties and a proper understanding of its nature. The chief aim of this discussion lies in the hope of contributing to the necessary preliminary process of clarification.

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Modern Glaciers of the Arapaho Massif

RONALD L. IVES

The author is well known to readers of THE SCIENTIFIC MONTHLY *for his many articles on the Lake Bonneville region and other areas of the Far West. Recently a member of the Department of Geography, Indiana University, he is at present occupied in teaching the "ins and outs of fire control and electronic computers" to airmen at Lowry Air Force Base, near Denver.*

EXISTENCE of large ice masses at the head of Boulder Creek, Colorado, has been known since the mid-1870s, when William H. Jackson visited and photographed the large morainal deposits there. Further exploration of the region, largely by Judge Junius Henderson and Fred Fair, prior to 1910, resulted in the discovery of more than a dozen ice fields within a few miles of the Arapaho peaks. About half of these have subsequently proved to be glaciers.

Until quite recently, these glaciers were so difficult of access that they were visited only by a few explorers, scientists, and adventurers, and their existence and exact location were only vaguely known to residents of near-by towns. Today the Arapaho and Henderson glaciers and the Arikaree Ice Field are parts of the water-supply system of the city of Boulder, and many of the other ice fields, tributary to St. Vrain Creek, are included in a large mountain recreation area, the Arapaho National Forest.

These glaciers and ice fields are clustered about the flanks of the Arapaho Massif (Fig. 1), a jumble of ice-carved peaks on the Continental Divide, at the heads of Boulder, St. Vrain, Arapaho, and Cascade creeks, about 65 miles northwest of Denver. Access to the glaciated area is by improved roads through Nederland, Eldora, Ward, or Granby; the glaciers may be reached by trail, but some of them are "restricted" because of water-supply use.

General appearance of the Arapaho Massif (Fig. 2) is quite typical of young or recently rejuvenated glaciated mountains in any part of the world, with sharp ridges, serrate peaks, deep U-shaped valleys, and paternoster lakes. Sharpness and sinuosity of the Continental Divide are notable here (Fig. 3). In some parts of the area, a strong man could shift the divide several yards in a few hours with a crowbar. Likewise, a few more centuries of glacial sapping may well cut through the cirque headwalls, creating glacial wind gaps through the thinner ridges, as at Rickety Ridge (Fig. 3), and at the same time remove the névé fields which support the present glaciers.

Summary topography of the Arapaho Massif, and of the valley and upland areas immediately adjacent, is shown in Fig. 4, a map from which minor and historical details have intentionaly been omitted.

The Glaciers and Ice Fields

Arapaho Glacier. Largest, best-known, and most easily visited glacier in this group is the Arapaho, located just east of the Continental Divide, between North and South Arapaho peaks, at the head of the Silver Lake Valley (Figs. 2, 4). The ice field has an area of about 100 acres and a thickness exceeding 75 feet, but probably not exceeding 400 feet. Névé fields feeding this glacier, either by slow

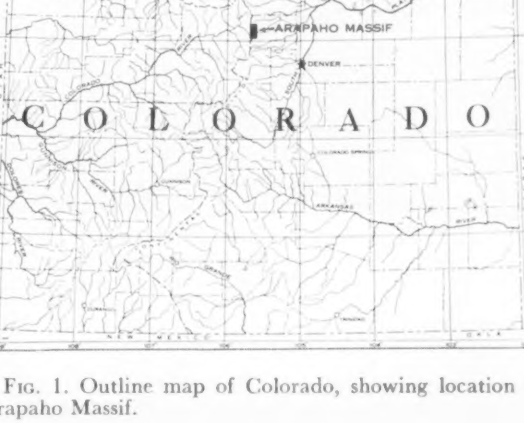

FIG. 1. Outline map of Colorado, showing location of Arapaho Massif.

creep or avalanche deposition, line the Continental Divide on the east side, here having a summit level of more than 13,200 feet.

Arapaho Glacier is best seen from a high saddle to the south, reached by trail from Fourth of July Gulch (Fig. 4). When viewed in late fall from this saddle, about 12,700 feet above sea level, the glacier appears as a stratified mass of dark-gray ice and rock, with a covering of relatively clean snow on the upper part, as in Fig. 5. The lower edge of this snow is commonly known as the *firn* line, and retreats upglacier as the season advances.

During early summer, which is the mountain spring, the glacier is largely covered with snow, and appears much as in Fig. 2. With the coming of the mountain winter, usually in mid-September, the ice is again covered with snow. Because of this climatic cycle, glacial ice is exposed for only about two months of the year. The snow between the firn line and the upper limit of the ice at the time of the first fall blizzard is buried and normally becomes a part of the glacier by compression and recrystallization. This annual snow increment, having a maximum thickness at the head of the glacier, and a sphenoidal shape, with apex downglacier, leads to a rotary motion of the ice and produces a marked headward dip of the ice bands near the glacial terminus.

Because the surface of snow atop the ice accumulates considerable dirt during the summer, there is a definite joint between old and new snow on the glacier. This remains as a dirt band when the firn becomes ice, and produces a definite stratification of the ice throughout the surface layer of the glacier. These dirt bands, which are commonly regarded as annual bands, much like tree rings, are visible in the exposed face of the ice (Fig. 6, right). Counts of the "annual" dirt

FIG. 2. The Arapaho Massif from the east. Distance from horizon to foreground is about 8 miles. At head of broad valley to the left are the Arapaho peaks, South and North, between which, occupying the "armchair" cirque, is the Arapaho Glacier. Slightly to the right is Henderson Glacier, smaller and at a higher elevation. Frozen lake in left foreground is Silver Lake, from which the valley takes its name. At extreme right is the Albion Valley, terminated by Arikaree and Navajo peaks, just below which is the Arikaree Ice Field. Clouds on horizon are on the western side of the Continental Divide, which here acts as a weather barrier, in addition to separating the Mississippi and Colorado drainages. Moraines of the early Wisconsin predecessors of the present glaciers are in the forested areas in the foreground. Large expanses of flat land at relatively high elevations are remnants of an earlier erosion surface, parts of which were glaciated. (Aerial photograph by Gordon Snow, Boulder, Colo.)

Fig. 3. View southward along Continental Divide from Apache Peak to James Peak. Snow in center foreground is névé field of Navajo Peak Glacier, above which is the peak. In lower left is the Arikaree Ice Field, and above it Arikaree Peak. Flat-topped peak in middle distance is North Arapaho Peak. Serrate ridge connecting Arikaree and North Arapaho peaks is the Continental Divide, locally known as "Rickety Ridge." Left slopes here drain to the Mississippi River system; those to right drain via the Colorado River to the Gulf of California. Note avalanche chutes bordering Wheeler Basin Hellhole, at right center. (Aerial photograph by Gordon Snow, Boulder, Colo.)

bands, in Arapaho and other Front Range glaciers, disclose numerous sequences of thin bands, separated by occasional thicker bands. Basal ice in the Arapaho Glacier is more than 300 years old, but presence of discontinuities in the dirt-band sequence, interpreted as evidence of periods when there was no carry-over firn, precludes estimation of a maximum age for the older ice. No clear correlation was found between the ice-band sequences in Arapaho Glacier and any well-recognized climatic cycle, such as the sunspot cycle or the Brückner cycle, nor has a relation been found between the glacial dirt-band sequence and the ring sequence in local trees. It appears that there are two local tree-ring sequences. Valley floor trees, rooted near the lake-maintained water table, never experience drought, and indicate, by their annual growth increments, only changes in thermal conditions, largely incident sunlight. Trees on the valley wall, in contrast, receive their moisture from meltwaters of minor local snowfields, so that their annual growth increments are influenced not only by thermal conditions, but also by melting of local snow, itself a function of amount of precipitation, available heat, and amount of snow removal and redistribution by wind. It is entirely possible that a complex, but valid, relation between dirt bands in local ice and tree rings in various locations can be determined, but evidence collected to date is inadequate for the purpose.

Motion of Arapaho Glacier is slow, probably not exceeding 25 feet per year. Evidence of this motion is audible in late summer, when the ice field pops and groans at night. Annual changes in the size, shape, and location of the small meltwater lake impounded by the moraine (Fig. 5) also show quite clearly that some motion is taking place.

Deep, wide crevasses in the face of the ice (Fig. 6) give clear evidence of lateral flexure of the glacier. The widest crevasse seen by the writer was five feet, with a depth of about 75 feet. Sound-

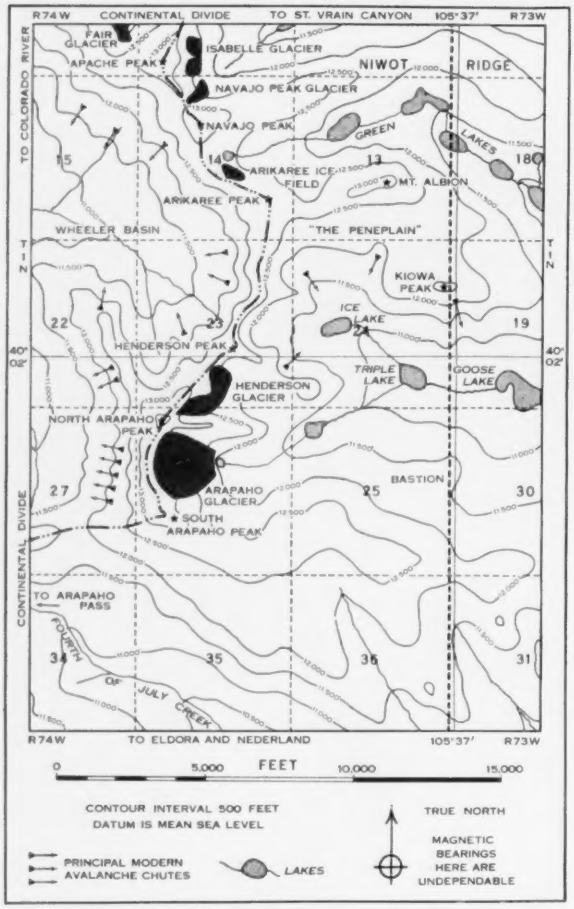

FIG. 4. Summary map of the Arapaho Massif, showing principal modern glacial features.

ing disclosed several feet of water in the bottom, which was only about five inches wide, and a probability of ice under the water. Crevasses and similar ice structures in the Arapaho Glacier are best observed from the summit of South Arapaho Peak (Figs. 4, 6), accessible without too much difficulty from the south saddle. Travel northward, toward North Arapaho Peak, should not be attempted by anyone not thoroughly familiar with the loose rock, unstable snowfields, and overhanging snow cornices common in this area.

The bergschrund of a glacier is a crevasse where the glacial ice pulls away from the cirque headwall, sometimes plucking out a part of the headwall. The bergschrund of Arapaho Glacier, in late summer (Fig. 6, left), usually follows the cirque headwall quite closely. Some years it is up to ten feet wide, and up to 40 feet deep.

Occasionally the meltwater lake between the ice and the terminal moraine disappears for a few weeks, because of erosion of the moraine dam or leakage beneath the moraine, and leaves an ice basin of considerable interest. On several occasions when this has happened, subglacial channels have been exposed, making ice caves large enough for a man to enter.

Henderson Glacier. Occupying a small high cirque just north of Arapaho Glacier, at the foot of North Arapaho Peak, is Henderson Glacier, a small mass of ice now about 50 acres in extent and not much more than 75 feet thick. This glacier is almost inaccessible, being on a high ledge not easily reached from any trail. Best route is by way of South Arapaho Peak, North Arapaho Peak, and thence down the névé fields, a traverse that requires mountaineering techniques, and is made hazardous by unstable rock and snow. Departure from the Henderson cirque is also difficult, usually entailing either descent of an unstable névé slope to the moraine of Arapaho Glacier, or of a polished avalanche chute to the Ice Lake Valley (Fig. 4).

General appearance of the southern part of Henderson Glacier is shown in Fig. 7. Evidence of marked recession of the ice in recent decades is given by the presence of the large black rock in the ice field (Fig. 7). In former years (about 1900), if this rock could be seen on July 1, irrigation water would be scarce. Now the rock is plainly visible in mid-May of most years.

Moraine of Henderson Glacier is a narrow ridge extending southward from the base of Henderson Peak, but there is a gap at the south end, permitting outflow of meltwaters. A shallow lake is impounded behind the moraine, but this is rapidly filling with rock flour and tundra growths.

At no very distant time in the past, Henderson Glacier was a tributary of the extended Arapaho Glacier system, and discharged both to the valley below Arapaho Glacier and into the Ice Lake Valley (Fig. 4). Morainal remnants, polished surfaces, and glacial grooving indicate plainly where the ice formerly traveled.

The Ice Lake Valley. Although it contains no glacier or permanent snowfields today, the Ice Lake Valley, just north of Henderson Glacier (Fig. 4), is of interest to the glaciologist as an example of probable future conditions in valleys now containing glaciers. The Ice Lake Valley differs topographically from adjacent valleys containing glaciers only in that the cirque headwall is quite low, causing a definite sag in the Continental Divide to the west (Figs. 2, 4). Because of the low cirque headwall, there is no very large névé-collecting area, so that any glacier that might form in the valley would literally "starve to death" in a very few decades.

Conditions in the Ice Lake Valley today are

Fig. 5. Arapaho Glacier, photographed from the south saddle at about 9:30 A. M. September 1, 1940. At this time of year, the snow cover is least. Note absence of névé field, presence of crevasses, morainal lake (lower right), and covering of morainal material on north (right) side of glacier. Banded rock on far wall of cirque is injection gneiss.

marginally glacial, with large snowbanks that may carry over for several seasons, but seldom last for as much as a decade before melting out during a hot summer following a winter with little precipitation. Rough computations suggest that an increase in winter precipitation of about three inches annually, or a decline in mean temperatures of only a few degrees (perhaps four), or a combination of both, would result in the reestablishment of a glacier in the Ice Lake Valley.

Because much of the Ice Lake Cirque is snow-free during the late summer, cirque floor conditions are beautifully exposed there. Several generations of polished surfaces, at various levels, complete with grooves and striae, which extend down the valley floor into the lake, are clearly visible. In some sheltered locations, glacial rock flour ("glacial clay") still remains in place, suggesting that the last glacier in the valley melted very recently, perhaps no longer ago than about 1880.

The Arikaree Ice Field. About half a mile north of the Ice Lake Valley, separated from it by an old erosion surface, now an elevated peneplain with and accessible from the Albion Valley (Fig. 4, striae and other evidence of glaciation upon it "Green Lakes"), is the Arikaree Ice Field, a ten-acre patch of ice partly filling the cirque between Arikaree and Navajo peaks (Figs. 3, 4, 8). This diminutive ice field contains "annual" dirt bands, and is separated from the cirque headwall by a large crevasse at the end of most summers. Whether this crevasse is a true bergschrund, caused by lateral ice motion, or is merely due to compaction of the ice and bottom melting, is undetermined. No other crevasses have been noted in the Arikaree Ice Field during the past two decades.

Moraine of the Arikaree Ice Field consists of a sharp ridge, much like the moraine of Henderson Glacier, but is backed up on the downvalley side by a large pitted plain of glacial debris (Fig.

8), which may be an older moraine, overridden by an ice advance perhaps half a century ago. Some glaciologists classify a ridge like that at the foot of the Arikaree Ice Field as a protalus rampart, rather than as a moraine, pointing out that much of the accumulated material now forming the ridge fell upon the ice, and slid across the top to its present position.

Névé slopes above Arikaree Ice Field are very small indeed, and entirely inadequate to maintain the glacier (?). Alimentation here is largely from snow that originally fell in Wheeler Basin (Fig. 4), and was later blown across the Continental Divide, to fall in the lee eddy created by air flow across Arikaree Peak, Navajo Peak, and adjacent parts of Rickety Ridge, by chinook and other westerly winds.

Presence of an ice field at the head of the Albion Valley, and not in the larger and deeper Ice Lake Valley, is due almost entirely to local air-flow and snow-drift conditions.

Navajo Peak Glacier. Unlike other ice fields in this region, the Navajo Peak Glacier (Figs. 4, 9) is a true hanging glacier, occupying a trough on the east side of the Continental Divide between Navajo and Apache peaks. This glacier has an areal extent of only about five acres, and a thickness estimated at only 75 feet. Because it is terminated on the lower end by a steep declivity, there is no terminal moraine, but on the valley floor, several hundred feet lower down, is a "dump," which receives random accretions of ice and rock. Because of this discharge, climbing upon or under the Navajo Peak Glacier is definitely not recommended, nor is skiing down the apparently gentle névé slope advisable. The gradient steepens downward, and the soft snow of the upper névé field is replaced by hard ice.

FIG. 6. Views of Arapaho Glacier from South Arapaho Peak, showing crevasses and release of contained rock (right), and bergschrund at cirque headwall (left). Photographs taken about 10:30 A. M. September 1, 1940. Dirt bands are visible in right center, and are cut obliquely by crevasses. Light bands in far wall of cirque (right) are felsite dikes intruded into Idaho Springs schist. Relatively smooth snow surface between firn line (left view) and bergschrund, which here follows cirque headwall quite closely, is characteristic. Rocks atop snow in left foreground are about 2 feet in diameter, and fell during the summer of 1940. Dirt atop snow at foot of avalanches chute in left middle distance was carried down by meltwaters.

FIG. 7. Henderson Glacier, as photographed in midsummer from the east. Morainal material in foreground is about 50 feet above the lower end of glacier. One access route is via the avalanche chute in upper left. Talus at left contains ice, and is unstable.

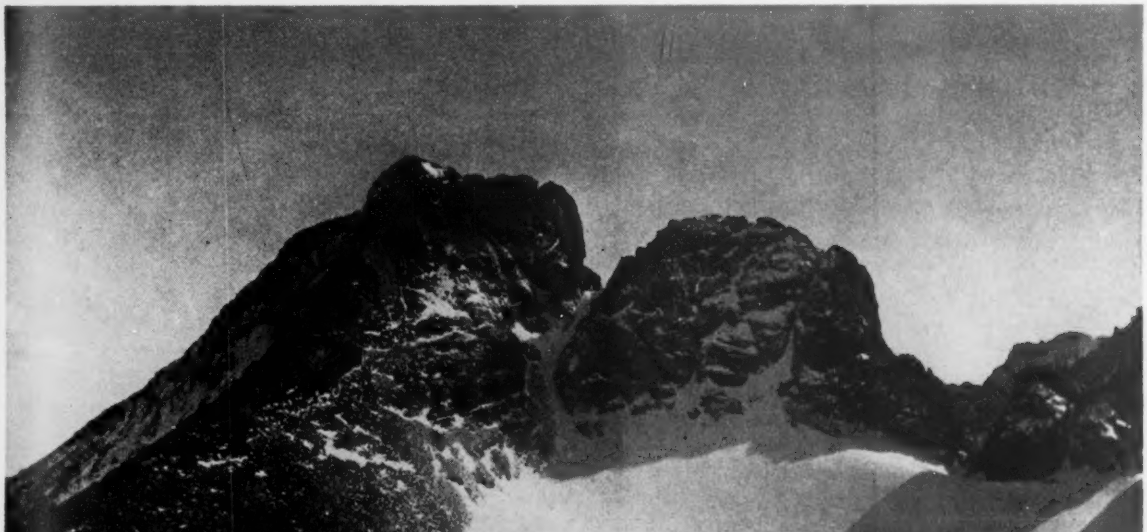

FIG. 8. Arikaree Ice Field, at the base of Arikaree Peak, as seen from the south chimney of Navajo Peak. This ice field, which is only about 300 feet high, may not be a glacier today, although it definitely was in the recent past. Note how the cirque headwall, which is also the Continental Divide, is penetrated (right).

Like the Arikaree Ice Field, the Navajo Peak Glacier is replenished largely by carry-over snow from Wheeler Basin, and owes its continued existence more to wind action than to precipitation.

On rare occasions, usually during the afternoons of late summer days, great blocks of ice, sometimes as large as a house, break loose from the snout of the Navajo Peak Glacier, and crash onto the valley floor several hundred feet below, the resultant noise and vibration echoing through the valley for several minutes, sometimes "triggering" slides in unstable talus slopes some distance away.

Isabelle Glacier. Intermediate in size between the Arapaho and Henderson glaciers, and northernmost member of this group, is the Isabelle Glacier, occupying a high bench on the east flank of Apache Peak, not far from the Navajo Peak Glacier (Figs. 4, 10). This glacier, an enlongated arc of ice, is about 800 feet long and 300 feet wide. Ice thickness may be as much as 200 feet in the center. It is probable that the Isabelle Glacier was joined to the Navajo Peak Glacier in the not very distant past, and that the connecting ice band melted within the past 100 years or so.

Perched on a bench high above the valley floor, the Isabelle Glacier is almost invisible from down-valley, but can be seen quite clearly from Niwot Ridge, and is not hard to reach from the valley floor, the ascent requiring only energy, and not skilled Alpinism. Because the St. Vrain Valley, into which Isabelle Glacier drains, is part of a public recreation area, access to the ice field is not restricted, and the area is one of the most accessible glaciated regions in the Rocky Mountains. Summer visits to Isabelle Glacier by way of Ward and Brainerd lakes, are "an easy day for a lady." Winter visits by personnel not skilled in mountaineering are not advised and too frequently result in a hard day for the coroner.

Other local ice fields. Not far from the Navajo Peak and Isabelle glaciers, but not easily accessible from them, is a group of ice fields on the western slope of the Front Range, at the headwaters of Cascade Creek, a tributary of the Colorado River. These ice fields, which include Fair and Peck Glaciers, line the rim of a deep ice-carved valley, locally known as the Crater Lake Hellhole.

This weirdly beautiful area, adjacent to, but not a part of, the Arapaho Massif, is accessible only by trail, the journey each way requiring a day's travel from the end of the road. Parts of it can be seen from peaks in the Arapaho Massif, but only a skilled mountaineer can reach the valley floor from these peaks.

Valley Features

Adjacent to, upon, and around the ice fields of the Arapaho Massif are numerous glacial valley features of great interest to the geomorphologist and student of the less common features of the earth's surface. Every valley in and near the Arapaho Massif is replete with solifluction phenomena, which duplicate on a large scale the myriad forms occurring in hot tar on a sloping roof.

Also resulting from solifluction are stone polygons, "Indian tent platforms," "sheep tracks," and similar geometric forms produced by repeated freezing and thawing of water-containing soil which is inclined. Much of the soil in the higher areas contains long spicules of ice as a permanent component, and resembles the permafrost soils of the Far North. Numerous small ponds, dammed by thick walls of turf, are present along some streams, often in a staircase arrangement. In flatter areas, circular ponds with walls elevated by ice thrust are found.

Beautifully developed annual layers are present in many of the lakes in this region, and are clearly visible in Lake Isabelle in late summer, when the water level is low. Complete sequences of delta beds, including topset, forest, and bottomset beds, first deposited from the meltwaters of the Navajo Peak and Isabelle glaciers and then incised by these same waters, are exposed at the head of the lake.

Nearer the ice fields, and particularly above

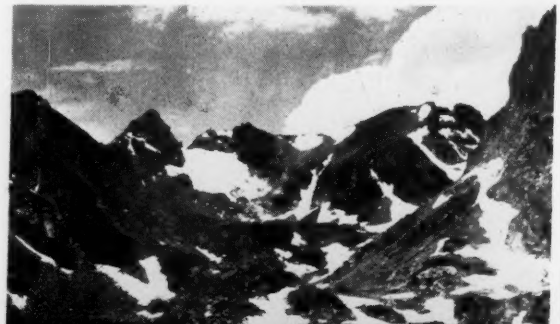

Fig. 9. Navajo Peak Glacier, at the head of the St. Vrain Valley, seen from the shore of Lake Isabelle. Navajo Peak is the conical mountain on the left skyline; the flat-topped ridge is Apache Peak. Large snowfield between them is Navajo Peak Glacier. Névé below and to right feeds Isabelle Glacier.

Fig. 10. Isabelle Glacier, photographed in early summer from the north flank of Niwot Ridge, above Lake Isabelle. Note perching of the moraine atop a great cyclopean stair, and the large talus at right. (Photograph by Charles F. Snow, Boulder, Colo.)

them, the rocks of the main range are being undermined and quarried away by the glaciers, and the picture is one of slow and systematic destruction. Each winter, great rocks, wedged free from the cirque walls by repeated freezing and thawing, fall to the valley floor. When these fall in late winter, and land atop heavy snow, they form a protective cap, so that later in the summer, a "toadstool," with a rock top and a snow stem, is produced. Such a feature is called an ice table (Fig. 11). Usually, these last for only a few months, and then topple over as the supporting snow "stem" weakens by melting.

Rock falls of all types are common in recently glaciated regions, and are rapidly removing the walls of many of the cirques. They may occur at any season, but are most common during the mountain spring, when loosened rocks are released from the ice that held them in place during the colder parts of the year. Shortly after the spring thaw, before the deep snow on the valley floors has melted away, these rock falls leave characteristic paths in the mountain snowfields (Fig. 12).

Quite spectacular in their appearance and occasional operation are the precipitous avalanche chutes on the higher valley walls. These, sometimes called "devil's slides," extend downward for as much as a third of a mile from the ridge crests to the valley floors, where they terminate in piles of rock or, in timbered areas, in great tangles of uprooted trees, shredded like chewed matchsticks.

Best development of avalanche chutes near the Arapaho Massif is in the Wheeler Basin Hellhole, just west of Rickety Ridge (Fig. 4), where numerous chutes and dumps are clearly visible (Fig. 13).

Fresh avalanche dumps contain large quantities of snow and ice, with occasional rock inclusions. Within a month or so, most of the ice and snow melts, leaving the rocks in a rather characteristic pile (Fig. 14), usually some distance from the valley wall. Because avalanches commonly

"take to the air" when the chute floor steepens, they often pass completely over small depressions. In most mountain regions there are tales of some local climber who has ridden an avalanche and survived. Although it is entirely possible to ride a small avalanche, the experience is both hazardous and unpleasant; and any description of a long ride on a large avalanche should be well seasoned with sodium chloride. Because of the great amount of material held in precarious equilibrium in many avalanche chutes, and of the very small stimulus (such as a revolver shot or even a loud yodel) needed to trigger some avalanches, it is customary, and advisable, to avoid avalanche-prone areas, such as Wheeler Basin (Fig. 4, 13), until all the major chutes have "fired," an occurrence usually taking place before mid-June.

Glacial Alimentation

Any competent statistician, using approved methods and unassailable climatic data, can demonstrate that the average direct snowfall is woefully insufficient to support glaciers in any part of the Colorado Front Range. It can also be demonstrated beyond any reasonable doubt that there are many glaciers in this area, and that these glaciers, although receding slightly at present, are not leftovers from past ice ages of 20,000 or more years ago.

In consequence, factors favoring glacial conditions in this area, other than direct precipitation, must exist. Field studies at all seasons disclose a number of such factors. These, operating together, seem adequate to account for the glaciers of the Arapaho Massif, and probably also for those in other parts of the Front Range area.

For the continued existence of a glacier in any area, alimentation must equal attrition plus overflow. If alimentation exceeds attrition the glacier will grow, whereas if attrition exceeds alimentation, the glacier will recede.

Glacial ablation here is retarded by natural shelters, the cirque and valley walls, carved by the glaciers themselves. These shade the ice fields,

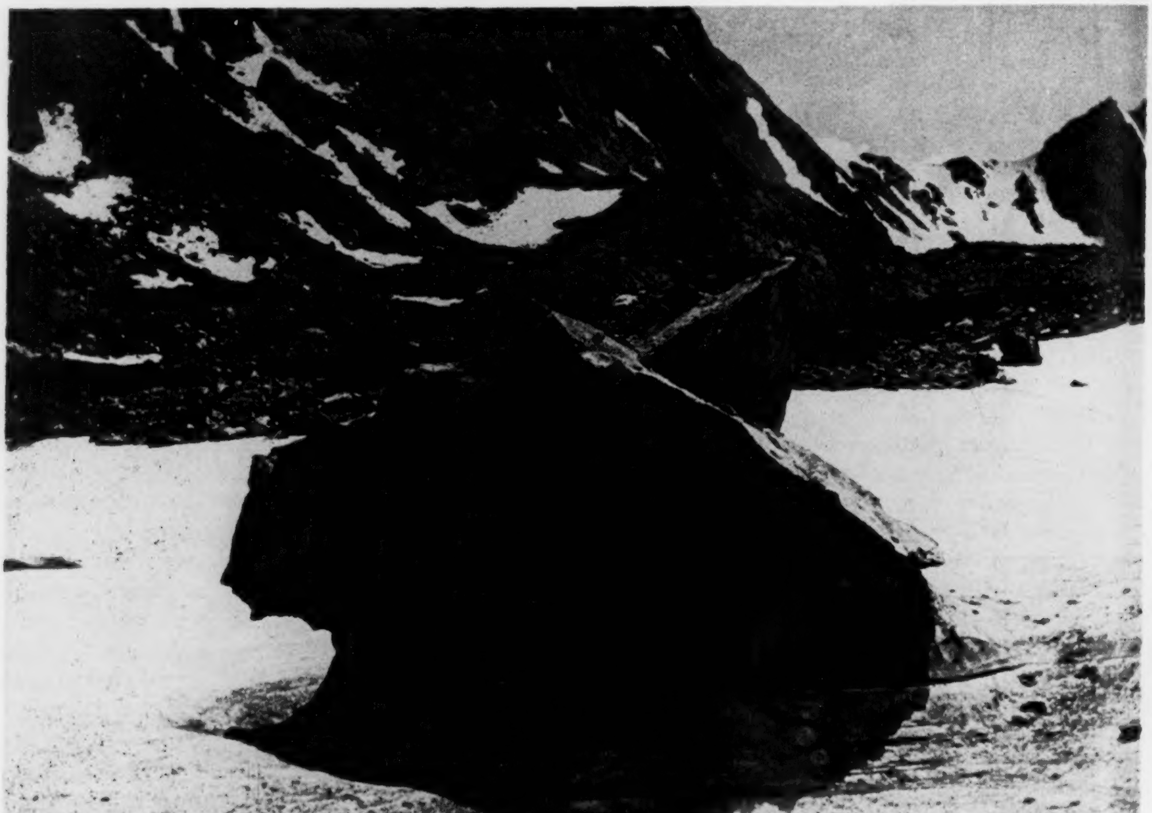

Fig. 11. An ice table about half a mile below Arapaho Glacier. These temporary features of the glacial landscape are produced when rocks fall onto heavy snow, protecting it, and the surrounding snow melts away.

FIG. 12. **Recent rock fall below Henderson Glacier, and characteristic rock fall marks in snow (background) produced by it. Larger rocks here are about 4 feet across.**

blocking off direct solar radiation, and retard melting. Likewise, the same shelter protects the ice fields from winds, and the steplike longitudinal profiles of the valley floors divert the warm daytime upvalley air drifts upward, and away from the glaciers.

Glacial alimentation consists of direct snowfall, which accounts for perhaps 30 per cent of the annual total; avalanche deposition; and carry-over snow, brought from the western side of the range by chinook and other winds, and deposited in lee eddies, many of which occur in the larger cirques.

When areas of augmented snow accumulation coincide with areas of reduced ablation, conditions favor establishment or continued existence of a glacier. Where such coincidence is absent, a glacier cannot be maintained. Without known exception, glaciers of the Colorado Front Range area occupy sheltered locations where both direct and redistributed precipitation are at a maximum.

FIG. 13. **Avalanche chutes and dumps in the Wheeler Basin Hellhole, on the west side of Rickety Ridge, photographed from North Arapaho Peak. Chutes, containing snow in their upper portions, angle downward from the crests. Near the valley floor, talus slopes fill an old glacial trench. Upon these, recent avalanche dumps (arrows, lower left) are superposed. Both dumps shown are composed of rock and snow, suggesting that they are only a few months old.**

Glacial History

All the valleys now occupied by glaciers in the Arapaho Massif were also carved to nearly their present profiles by glaciers, but not by the present glaciers. Lengthy field investigations in the Front Range area, by a large number of workers, disclose that ice formerly extended from the Continental Divide to about ten miles east and fourteen miles west of it, down to altitudes of not much above 8,000 feet.

Glacial chronologies of the Rocky Mountain region are numerous, and by no means in perfect agreement. Most glaciologists are agreed, however, that Pleistocene glaciation in the Rocky Mountains was not simple, and that there were two or more separate ice advances in later Pleistocene time—during the last half million years or so. The more thorough workers have found considerable evidence that these ice advances consisted of numerous advances, stadia, and retreats, evidenced by multiple morainal ridges in parts of most valleys.

Major evidence from all parts of the Front Range is similar, but the glacial history of each valley system seems unique, when interpretation of the minor and complicated morainal patterns is attempted. Although the major periods of refrigeration during the Pleistocene were undoubtedly caused by world-wide changes in climate, the local manifestations of these changes need not have been identical, and probably were not. Certainly the various glaciers of the present are not identical in either appearance or behavior.

It now appears that all serious attempts at glacial chronologies in the Rocky Mountain region contain substantial elements of correctness, that the discrepancies between them may be more apparent than real, and that some of these discrepancies are evidence of past local glacial variations, of about the same relative magnitude as present local glacial differences.

FIG. 14. Avalanche dump, about two months old, on the floor of the Ice Lake Valley. Most of the ice and snow has melted out of this dump, but its location some distance from the valley wall, with intervening snow unscarred, indicates that it was avalanche deposit, and not a slide.

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Symposium on Viewpoints, Problems, and Methods of Research in Urban Areas

The program of Section K (Social Sciences) of the American Association for the Advancement of Science, held in Cleveland in December 1950, was weighted heavily in the direction of interdisciplinary participation. One session of this program, as arranged by Chairman Ernest W. Burgess, was designed to show how various disciplines are both alike and different with respect to the study of urban areal problems. The session itself was given over to informal discussion which used as a starting point seven papers prepared, respectively, by two biologists, two geographers, one economist, and two sociologists, each of the latter limiting his discussion to demography or human ecology. James A. Quinn presided over the symposium. The following pages give summaries of the seven papers, together with brief concluding comments by the chairman.

Biology and Urban Areal Research

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A QUARTER of a century has elapsed since Professor Burgess published selected papers from the *Proceedings of the American Sociological Society* under the title *The Urban Community.* To judge from its pages, although it was fashionable at the time to dissociate biology from sociology, many sociologists of the day were thoroughly conversant with the progress of biological thought and had frequent recourse to its concepts. The analogy of the community as a living organism, the ecological processes of competition and succession, the trends of evolution—these and other biological ideas leavened the bread of sociology in the twenties. The intervening years have seen a gradual rapprochement between the biological and social sciences. Nevertheless, the complexities of present-day problems require an even closer cooperation, such as that envisaged in the development of the modern research team. Something more efficient is called for than the old-fashioned type of expeditionary force that included among its impedimenta a handful of scientists, each of whom worked quite independently of the others. The up-to-date task force required for an attack upon the problems of the urban community must have a highly developed and effective system of intercommunication. A frank discussion of the similarities and differences in outlook and techniques employed by the several groups interested in these problems can be of great service in this respect. What, then, is the point of view of biology in terms of its approach and research methods as they are, or might be, applied to urban areal research?

The biologist approaches his subject from the standpoint of structure, function, development, and adaptation. He may do this at any one of a number of different levels: the cell, the individual, the population, the community. To these he has recently added a fifth level, which Tansley[1] calls the *ecosystem.* This combines in a single unit the living community of plants and animals and the nonliving environment with which it interacts. Fundamentally, it is a complex structure of pathways and storehouses for the absorption, accumulation, circulation, and removal of energy and matter at various rates and in varying quantities. Although no natural ecosystem has as yet been thoroughly investigated or understood, the concept has had considerable influence in the field of community ecology. In human affairs, the ecosystem finds a close parallel in the essential unity of the city and its hinterland. The extraordinary capacity of man to free himself from the limitations of his physical

and biological environment and to create for himself a social and cultural environment does not seriously weaken the analogy. The growth and development of a human community are marked by changes in its energy budget, as seen in its productivity, consumption, and rate of energy circulation. Modern transportation and communication notwithstanding, the availability of resources needed by the urban community has a profound effect upon the nature of its energy utilization, just as geography and topography may influence its shape and structure.

In the ecosystem concept, then, pattern and process are brought into synthesis, giving rise to the problem of regulation. The fact that the community, like the individual organism, maintains a more or less constant *milieu intérieur* in the face of changing environmental conditions implies the operation of regulatory mechanisms. Competition, parasitism, predation, and the like are important forces in the regulation of natural communities and have their counterparts among the "fauna and flora" of urban social life. Current ecological thought espouses a theory of population control in terms of the interlocking and intercompensatory action of multiple regulatory mechanisms.[2] The more complex the ecosystem, the greater the number of potential regulating agencies, and the less the likelihood of violent and disturbing fluctuations. Human communities are no exception to this rule so far as the physical environment is concerned, for the rise of the city has been possible only through man's domination of his surroundings. It must not be forgotten, however, that *manipulation* does not necessarily mean *control*. This is particularly true in reference to man's social and economic environment, the increasing complexity of which has been accompanied by ever-growing stresses and strains. Behind the disharmonies of the modern urban community there seems to lie a lack of effective regulation. To quote from Sears,[3]

> The record of man's efforts to alleviate these tensions is thus far not very heartening. They are in general piecemeal, stopgap, emergency measures, applied at the point of most obvious stress. Not until the problem is viewed in its entirety, in terms of what Ostwald so wisely called "The Imperative of Energetics," can we hope for relief from the maladjustments of our own causing.

A correlative problem for the biologist is that of change. In the past twenty-five years, much progress has been made in elucidating the influence of heredity and environment upon organic evolution. This period has witnessed the development of mathematical and statistical genetics, considerable clarification of the roles of mutation, selection, and isolation in the origin of species, and important contributions to the study of evolutionary rates. That similar forces are operative in cultural differentiation and that they affect our social inheritance can hardly be doubted. The urban area offers the best of natural laboratories in which to study the interaction of biological and social factors in the evolution of man. Biologists are in general agreement that small, partially isolated populations favor rapid differentiation of type. The formation of the city has enormously accentuated the "contagious" distribution of mankind and has resulted in the development of discrete populations which, though large in the aggregate, are broken up into many smaller units by numerous social and cultural barriers. On the other hand, it may be argued that urban conditions have created a situation favorable to rapid generalization of human type and that the high degree of mobility possessed by modern populations tends to vitiate their isolation. As a matter of fact, we know very little as yet about the genetic constitution of urban populations or their breeding structure. How much do immigration and emigration influence genetic drift? How has the selection in favor of city-adapted traits affected the character of the urban population? How does the proportional increase of the older, nonreproductive element in the population change the genetic structure? Here are aspects of urban areal research that are of mutual interest to the biologist and the sociologist. For, as Dobzhansky and Ashley Montagu[4] point out, man's social environment favors those individuals with the greatest capacity to invent new adaptive responses, which are the source and mainspring of human culture.

This cursory treatment of the relation of biology to urban areal research has of necessity been highly selective. It has attempted to show that the fundamental concern of the biologist is with the same problems and processes that confront the social scientist, and it has tried to indicate the distinctive nature of the biological approach. Little if anything has been said about methods. Discoveries or inventions, in whatever field of science, seem to take place in rare moments of sudden insight;[5] in the words of the poet, "they flash upon the inward eye," often at unpredictable occasions. Such insight is the result of a fruitful combination of concepts hitherto unrelated. This paper, then, is dedicated to the sharing of ideas.

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The Application of Biologic Research Methods to Urban Areal Problems

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ANY biological human areal problem is a phase of human ecology—that general subject which deals with the relations and interrelations between nature in general and human nature in particular. This, therefore, means from the broadest possible point of view and with all of its ramifications. It requires considerable effort to grasp the full meaning of this dynamic interrelation, the implications involved in this kind of unity, and the general point of view.

The general drift of modern science has been from the static interpretation of relations to a genetic and dynamic one of processes. The physical world is undergoing constant change, living organisms are likewise undergoing similar changes, and the constant interaction between these major series of processes, as Herbert Spencer long ago pointed out, constitutes the essence of the living organism. The major human problem is therefore to make the adjustment between these general processes of nature and the processes of human nature. This fundamental relation is all too often overlooked or ignored, and research is often not planned to solve it.

The practical ecological problem is to secure the integration of these two major series of sequences—the "natural" and the "social"—and to understand their dynamic relations and modes of action, in order to adapt them to human advantage—the *major* integration needed.

There is a natural classification or hierarchy among organisms as a result of their evolutionary development—simple and complex plants, simple and complex animals—each of which has its own order or sequence of development and life history. This is the source of the great diversity in the organic world and in man. There are also natural classifications, or a hierarchy of environments, physical, biological, social, and cultural; and each has its own orderly sequence and developmental order of action, and developmental history. Order and sequence operate at each horizontal hierarchic level—physical, biological, and social—with certain dynamic relations operating at all levels, and some only or mainly at certain levels. At all levels pressures exist, adjustments are made to pressures, and relative equilibria are established; but some social pressures exist only at the social cultural level. In addition to the lateral dynamics at various levels, there are also vertical pressures; and the integration of these two series is of the greatest importance, as they require definite recognition for practical use. For example, what Cannon calls the physiological "wisdom of the body," that which maintains a healthy physiological state, is subordinated to the higher levels for the welfare of the individual organism as a whole, and may be further integrated by man's intelligent behavior as a member of society. This is man's major integration, and it establishes a new equilibrium and level.

The recognition of these dynamic relations, and the organization and formulation of the questions and the problems in such a form that the evidence for the operation of the processes will conform to the appropriate mathematical processes, is of great importance. It is also desirable to give the mathematical processes practical verbal expression, so that the horizontal and vertical dynamics are clearly understood and consciously integrated for action on urban areal problems.

A critical step in this process of orientation is the attitude of the research worker himself. The same general concepts that were applied to the orientation of the problem and the application of the dynamic and genetic standpoint apply to the worker himself. He must learn to think in dynamic and genetic terms with regard to the general processes of nature and of human nature before he can apply the self-correcting methods of science. And at the same time, because science is interpersonal and democratic, he will apply the self-correcting methods of democracy to the problem.

For the research worker there must also be relative freedom of thought and of integrity, or there is no reliability in the research methods and results. We commonly assume these qualities, but we know that they must be demanded as essential. This calls for intellectual and emotional honesty, which is probably best developed in healthy, normal, balanced personalities. This is also probably the kind of personality most needed in order to develop and maintain the best form of social community life. The justification for such research personalities is that there must be such persons, or a combination

of personalities that have such an appreciation, or the appropriate methods will not be utilized to find the facts required for a complete study.

When possible, a research program should also provide a plan or program by which the research may be executed, and include a nucleus of trained workers who are capable of participating in its formation and its execution, or it may remain foreign to the local urban area and fail of assimilation.

All the preceding remarks have been concerned with the processes and dynamics of the human orientation. When the urban local problem is considered, the same kind of orientation in thinking is necessary. The same kind of research processes apply with equal appropriateness and validity; the same dynamic processes and developmental sequences operate at horizontal and vertical levels; and corresponding integrations are required so that the research may be organized to give explicit answers to many questions. There is nothing essentially different in method, only in degree of application.

I cannot refrain from calling attention to what may be one of the supreme urban problems. Community studies of plants and animals have suggested the hypothesis that a favorable life for an organism implies conditions which permit an indefinite occupation of an area under a particular set of conditions, produced by a dynamic balancing of all conditions, a relative equilibrium, and an apparent optimum. Small human communities often show a similar balance under certain conditions, suggesting that here is involved a sort of climax, or the culmination and balancing of all the regional conditions. This also assumes that a fundamental change of the environment will require a new adjustment and the development of a new equilibrium.

As a working hypothesis this may also prove of value in the study of concentrated human urban communities. Under modern congested urban conditions the population does not tend to maintain itself; it is constantly recruited from less concentrated areas. We must never overlook the fact that urban problems must be considered a part of the larger urban-rural situation. This suggests the need of research on this problem. Is human life under these congested conditions normal, healthy, and self-sustaining? Are public hysteria, the aberrations of mass psychology and psychosomatic diseases indications of an abnormal life? Must cities be radically reorganized and made a suitable place to live, or must urban people be considered expendable as the price to be paid for the urban culture they produce? One wonders also if these general antiorganic conditions—physical and mental—are related to the decline of past civilizations.

Finally, I should add that the self-correcting methods of science cannot be permanently maintained except under a comparable system of self-correcting democracy, as the relation between these two methods is a dynamic reciprocal one of mutual dependence. I see no other sound procedure than the integration of these two methods, the scientific, and the democratic social method. Only by such means can the integrity of the individual and the obligations of society be joined to produce the highest type of personality.

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Geography and Urbanism

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IN RECENT years, geographers have in increasing numbers been turning their attention to the study of urban areas and the problems of cities, and a substantial number have adopted urban geography as their primary field of specialization. Some of them have been attracted to fields of application of their specialization in which geographic concepts have made valuable contributions, as in city planning, public administration, marketing, and local transportation.

Urban geography has a distinctive focus. Its primary concern is the association of activities in

urban areas, which are expressed in characteristic associations of land use and occupance features. Thus the center of interest of urban geography, as of all geography, is man, and the reciprocal relationships between man, his works, and the earth. It is concerned with interpreting the patterns and relationships that exist within urban areas on the one hand, and between urban areas and the non-urban areas that cities serve, on the other.

Many geographers of an earlier generation attributed to the physical environment a deterministic role and an influence which precluded the exercise of the wide range of choice of alternative modes and patterns of physical and cultural development which we now know is available to man. Few geographers today hold that the environment determines the form and patterns of culture; most hold firmly the conviction that the most important environmental influence is man himself. They believe that, within very broad limits, the environment can be made to serve man rather than be his master; that, with sufficient social and economic motivation, the limitations of the environment which circumscribe man's choice among alternative forms of relation to it are very elastic and flexible.

Modern geographers hold that the activities of man, the physical forms or structures developed for those activities, and their arrangements and associations with one another and with the land, are at least as much a reflection of the cultural framework within which they exist and which they are intended to serve as they are a reflection of the relationships with the natural environment. Many geographers ascribe to culture the more important role. It follows, then, that urban geographers must be familiar with the historical, social, economic, and political background of the areas within which cities are located.

Urban geography is concerned with the study of the economic base of cities; with interpretation of the relationships between the city as an important form of man's occupance of the land and the activities within the city's hinterland or economically contributary area which focus upon the city and which give rise to urban occupance. It is not possible, for example, to understand the extent and patterns of industrial and commercial areas within urban agglomerations without an understanding of the nature and distribution of those activities that produce raw materials for the industries, carry the materials to the factories and the products to the markets and the consumers, convert the materials into marketable products, and use the products to secure economic and social advantages.

Cities exist primarily to provide goods and services for the people who live outside the urban boundaries. No city can exist purely as a self-sufficient unit; it is a focus or area of concentration for a variety of activities serving areas beyond the city itself. In return for such activities and services, cities receive, directly or indirectly, sustenance from the areas which they serve. The extent to which any given urban activity serves the people outside the urban area is a measure of the relative importance of that activity as an urbanizing force. The economist devises measures of the relative importance of these activities; the geographer studies them in association with each other. He measures and interprets their relative importance in the various portions of the area the city serves, and the location, intensity, and character of occupance of the land within the city itself which is used or is potentially usable for servicing those activities. Thus, studies of the location of industry, of the amount of land used by industry, of the amount of land potentially usable by industry, of the numbers of persons who are, now or potentially, supported by various industries, and the changes that have occurred, are occurring, or may occur, among the various industries within a city, are vital concerns of the urban geographer. Similarly, the geographer is concerned with the relations between industrial land use in cities and the other forms of occupance of urban land. The relations, for example, between locations of employment—the industrial and commercial areas—and places of living—the residential areas and associated community recreational, educational, shopping, and other service areas—are reflected in the amount, direction, time, and character of movement of persons between the various functional areas that together comprise the urban agglomeration. Transportation thus makes possible the differentiation of functional areas characterized by different forms and combinations of forms of occupance. The study of transportation, therefore, both intraurban and interurban, is a concern of the urban geographer.

A city cannot be considered as an isolated physical or social unit. It must be considered primarily as a focal area for activities—expressed in physical forms such as buildings, streets, and parks, and in social forms such as institutions, customs, and mores —for a much larger area, the size and extent of which vary for each urban function. The measure of the extent of these urban relationships, of the differences of extent from one city as compared with another, of the influence of one activity as compared with another from a given city, and the description and interpretation of these differences

are concerns of the urban geographer. In such description and interpretation the geographer calls upon many related disciplines, from sociology, anthropology, and political science to engineering, architecture, meteorology, pedology, geomorphology, and even psychology. Specialists in each of these fields may describe and interpret the spatial distribution of those groups of phenomena with which each is especially concerned; only the geographer is concerned with all the interrelationships among them as they exist within an area, and as they differ from one area to another. The urban geographer is thus concerned with the city as a functional as well as a physical entity. He is concerned with the environments of cities as well as with the environments within cities; with the patterns of distribution of cities on the earth as well as with the pattern of distribution of people, buildings, facilities, institutions, and cultures within cities. He is concerned with the interpretations of these distributions and their differences in occurrence and intensity from place to place, insofar as interpretations may be found in the interrelationships among the various phenomena thus distributed. He is particularly, though by no means exclusively, concerned with the study and interpretation of areal differences in the relationships between man and his institutions on the one hand, and the environment, both physical and social, on the other.

Having concluded that the functions and forms of urban occupance are, to a large extent, within the control of man, and being concerned with the relations among these functions and forms in their spatial arrangement, it follows logically that the urban geographer should be concerned with describing and understanding the spatial frictions existing in cities and inhibiting the fulfillment of the maximum social and economic potentialities of urbanism as a form of land occupance and as a way of life. It is a short step from the study of alternative types of spatial relationships to the furnishing of guidance in the selection from among the many alternatives with which man is confronted. The urban geographer, therefore, is concerned with the problem of guiding urban growth and development into such forms and patterns as will further the attainment of a better urban way of life. The guidance of population density in cities through control of land use and the provision of instruments by which the character, density, and distribution of housing and residential areas can be made better to serve the needs of the population; the securing of better relationships spatially and functionally among the various forms of land use in cities; the reduction of the frictions of competition among alternative land uses by proper allocation of land through zoning and other forms of democratic public action; the reduction of the time- and energy-wasting journeys between home and work; the securing of a better physical urban environment through guidance of city growth into more acceptable forms than the sprawl which now characterizes most urban areas—these are objectives that many urban geographers hold to be challenges worthy of the most intense application of geographical knowledge.

A Geographer's Approach to Urban Study*

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GEOGRAPHICALLY viewed, a city is a segment of the earth that has become differentiated from its surrounding rural areas in functions, appearance, and attitudes. Although its boundaries may be hard to determine, its core is clearly set apart by the forms that expess its functions; that is, the use of the land is distinctive.

Urban units range in population from market towns to world metropolises, and their number varies inversely with their population. Whether they are spaced close together or far apart depends upon the total population—rural and urban. They tend to be arranged in regular geometric form, but their spacing is greatly modified by inequalities of the earth's surface and resources. Exceptions to regular spacing vary directly with population—the larger the city, the less closely it conforms to a rule.

The functions of urban units are similar everywhere, but each major social order has created cities that express its particular attitudes and tradi-

* *Apologia*: The points made here express only my personal views, and in no sense represent the geographic profession. My interest in cities has been lifelong, but pragmatic rather than comprehensive. For many years I have taught classes in the field, mainly in Chicago and Boston, and some of my own field studies of urban areas have been published. I make no pretense of having covered the literature of urban geography, much less that of other disciplines concerned with the urban scene.

tions. The distribution, population, area, appearance, and internal structure differ to the extent that these attitudes and traditions differ. The chief styles of city are: Oriental (south and east Asia); Levantine (Moslem world); Occidental (Europe); and Occidental modifications (new continents settled by Europeans, and black Africa).

Some of the societal differences may have sprung from the natural environment, but the earth also conditions urban units directly, entering into their distribution, population, area, appearance, and internal structure. The ways and degrees to which cities conform to earth conditions, and the measure of their resistance to those conditions, may be traced under two heads: location and site.

Location. A city's location is the unique place from which urban functions can best serve the surrounding articulated area and profit most from it. In theory, this is the geometrical center, but other aspects of area modify the theory in varying degrees —for example, density and distribution of population, drainage pattern, modes of transport, ruggedness and pattern of terrain, local climate, productivity, localized resources (especially minerals), and defensibility.

True central location is most likely to be attained in the smallest nodes, i.e., those least significant. No metropolis of the first rank is geometrically centered, although each one lies within a district where the natural environment is highly favorable to the specific functions performed by that particular conurbation. Location is often set by some particular earth feature or resource: a mountain passway, conjunction of coking coal and iron ore, a confluence of navigable waterways, a highland in humid tropics.

Site. The site occupied by a very small town may be uniform, but most cities have outgrown their original site, and have spread out over different kinds of ground. In such variety, the salient unit is usually the commercial core, and in most cases includes the original point of attachment where the city took root. This significant site may be cited as that of the whole conurbation: harborside, sandy river terrace, defensible hill, rocky margin of an oasis, natural levee, piedmont alluvial fan, islet.

Within the city, varieties of site are utilized for different functions. Heavy manufacturing industries and playing fields gravitate to flat land. Cemeteries locate on the best-drained areas, especially if wooded. Residences range widely, but the highest quality is usually on high ground, unless steep slope or bedrock impairs access or interferes with construction; conversely, floodplains are notably undesirable. Local climate may affect the quality of residential sites. Commercial functions keep to flat land or gentle slopes wherever possible. A shopping thoroughfare will turn corners to avoid steep grades.

Failure to recognize the inherent values of site frequently set man and nature in opposition, as where a rectilinear grid, eminently suitable for a piece of flat ground, is rigidly imposed upon steep hills, as in San Francisco. In extreme cases natural conditions may prevent execution of the plan; more often, all succeeding generations suffer from its unwisdom.

Inside the city, differences of site and also distance (space) may operate in connection with location. A common case is symbiotic function, as where leather wholesaling, tanning, and shoemaking are localized in separated sections of a single metropolitan district. Site qualities may be offset by location: positively, as where two identical sites used for residences differ in population density, architecture, and upkeep, because one is less accessible to "downtown" than the other; negatively, as where two separate types of terrain bear similar housing because of equal nearness to town.

Sequence. With passage of time, every city undergoes change—in area, population, pattern of communications, style and material of its architecture, upkeep. Very rarely, and usually accompanying a major change in mode of life, location becomes so outmoded that the city declines or disappears. If the site is outgrown or, as happens frequently, outmoded, it may be drastically altered, as by leveling hills or filling in marshes or waterland.

In growing cities certain areas rise or decline in utility. The shift from farmland to suburb on the urban periphery is well known; the decay of residential areas just outside the commercial core is hardly less familiar. The same principle operates where the land use shifts from one urban function to another, as where a broad thoroughfare lined with fine residences turns into automobile row. The clustering together of competitive business houses intensifies with increase in the number of firms engaged and may encroach upon land earlier used for some other purpose. In all these changes location and site are basic. They always operate on the principle that each kind of site has its inherent optimum utility, modified by its location.

Changes may occur piecemeal and spontaneously, or they may be planned. In many instances the two overlap, as when a residential subdivision is

laid out, (i.e., planned), but without reference to the existing city other than adjacence.

Spontaneous change in utility or function of a street or a district commonly leaves a residue of relict forms, such as narrow streets, demoded houses, lots too small for reconstruction suited to new use. Such a district can be regenerated, but it is likely to require action by the city or other government, to clear the way for planning. Most housing redevelopments are of this kind. Unfortunately they too rarely take account of location and site.

Different in origin is the persistence of old modes in new construction, because of inertia or conscious imitation in the face of more appropriate use of ground space, building materials, and site. Thus, new frame structures may jostle one another and create fire hazards. Wooded, rolling sites may be levelled off to monotonous, treeless flats before being built up with residences.

Perhaps the most fundamental element in the evolution of a city is the street pattern. The direction, continuity, width, and connections of a street determine the uses to which it will be put, provided it conforms reasonably to the varying site features it traverses.

A rock outcrop, a precipitous slope, deep water, or other obstacle may disrupt an unwisely planned plot of streets, but awkward grades, costly causeways, and endless annoyance are more apt to result. Streets laid out in harmony with features of the natural environment subsequently altered are equal nuisances, but with more justification; for example, the "cowpath" streets of downtown Boston once skirted shorelines and followed contours.

Over-all planning in urban areas can ameliorate ill effects of planless evolution, provided adequate attention is paid to the alterable but eternal earth factors of location and site.

Demography and Urban Areal Studies

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THIS statement is concerned with the point of view of demography—its approach, problems, and research methods—as they are or may be applied in urban areal studies. It is summary and suggestive rather than exhaustive and complete.

Demography, as ordinarily understood, may be defined as "the numerical analysis of the state and movement of human population inclusive of census enumeration and registration of vital processes and of whatever quantitative statistical analysis can be made of the state and movement of population on the basis of fundamental census and registration data."[1] Demography has both static and dynamic aspects. It furnishes raw materials or data for use in all social sciences, including urban areal studies.

Agencies responsible for the collection and publication of demographic data seldom go beyond these stages, primarily because of budgetary and policy factors. If demographic activity were to stop at this level, however, it would be relatively sterile. It remains the task of other professions to discover and analyze relationships both among the demographic data themselves and between demographic and nondemographic phenomena. This is precisely what such disciplines as human geography, human ecology, economics, and urban sociology have to do with demography per se.[2] The range of subjects investigated by scholars in these other sciences extends from standard studies of migration through analyses of "dominance" by Bogue and to the first steps toward "social physics" by John Q. Stewart and the late G. K. Zipf.*

Problems. In acting as a service discipline to social sciences, demography is plagued with the necessity for making numerous decisions. For example, what shall be the exact scope of demography: shall it be limited to assembly of statistics on age, sex, nationality, occupation, and housing, or shall it extend to relating these statistics to other phenomena?

Enumeration and registration agencies face many problems of refinement of techniques. Coping with sampling difficulties, resolving distortions incidental to the high mobility of urban population, and achieving comparability of data—especially if any attempts are made at reconciling enumeration units with ecological units—are representative of the

* Space limitations make it feasible to illustrate subsequent discussion by reference to agency publications only. Such publications are, of course, fewer in number than those from other sources.

problems encountered in dealing with urban data alone.

For persons making urban areal studies, many of the problems of demography relate directly to the methods of the field. Here the word "methods" is defined broadly and includes the following: (*a*) determination of the content of their data, (*b*) manipulation of the data, and (*c*) presentation of the data.

Methods.† Both decennial census and registration agencies focus their activities on the assembly of data according to a plan for continuing various series that have utility for the general public; and they serve only in a limited way such special publics as persons doing research on urban affairs. Naturally, emphasis is placed on accuracy and comparability. The specialist is generally aware of the limits of accuracy attainable with the given cumbersome machinery and is ordinarily willing to work with these limits in mind, since efforts to extend them would soon pass beyond the point of diminishing returns. The problem of comparability, however, seems amenable to improvement. For example, it would seem desirable to effect a more usable delineation of enumeration and tabulation areas than at present exists. The national- and local-level conferences that resulted in the formation of "standard metropolitan area" definitions for the 1950 census, for example, might profitably extend their work to the consideration of enumeration districts, census tracts, communities, and other areas.

a) It has been claimed that available census and registration data are greatly underused and that there is accordingly little case to be made for enlarging coverage. Certain additions, however, do seem in order. For example, it is regrettable that there was no systematic coverage of wartime shifts of population: an intercensal sample enumeration for 1945, for instance, would have been a welcome supplement to ration board statistics and would have permitted making many illuminating studies. Similarly, now that urban society is characterized largely by separation of place of residence from place of daily activity, account should be taken of *daytime* population as compared with *nighttime* population recorded in the census.

b) Demographers often manipulate the data they assemble. Here they can join forces with others making urban areal studies. The calculation of rates and the observation of gradients, along with determination of density data and similar measures are more and more taking place within a larger framework relating them or other urban phenomena. The computations involved in projection likewise are being refined, as are correlation techniques.

The alleged underuse of block tabulations from the 1940 census may be a result not so much of ignoring the existence of these resources but of the lack of such supplementary tools as coding guides that would make it possible to relate other types of data to census data.‡ The ordinary isolated researcher, and even groups of researchers, cannot marshal resources for preparing such codes; there may be a chance here for utilizing existing data by way of joint activity among data-consuming groups in an urban area.

c) Methods of presentation of census and registration data, and of the findings of demographic studies based on them, constitute another problem area. The Bureau of the Census has recently published a volume on tabular presentation which should have the effect of improving one of our research tools.[3] This is a welcome addition to mere tabulations and population pyramids.

The occasional monographs published by the Bureau of the Census—two in the 1940 series as contrasted with eleven based on 1920 data—need to be prepared in larger numbers if the needs of urban areal studies are to be served. One is reminded of the 1880s and 1890s with their *Social Statistics of Cities* volumes, which related demographic to other types of data.[4] Urban areal studies would benefit by having available the full range of data suggested several years ago by the National Resources Committee.[5]

Special mention may also be made of the potential gains from the preparation of an urban statistical atlas. Although the burden of mapping local urban data is clearly upon the shoulders of local research personnel, selected characteristics of nation- and state-wide importance might well be given cartographic presentation by Federal and state agencies. Many a hypothesis turned into a respectable research project can trace its origin to an analysis of mapped data.

Although mainly official census and registration activities have been discussed in this summary, much of what has been said applies equally well to the research products of demography in general. It is evident that demographers and persons making urban areal studies could profit mutually by joint attention to their approach, their problems, and their methods. The gratifying aspect of the situation is that this kind of activity is on the increase,

† This statement is limited to the discussion of methods as they affect urban areal studies.

‡ Reference is made to street address coding guides that permit allocation of data identified by street address into enumeration districts or census tracts.

as in the case of the Bureau of the Census–Scripps Foundation program, and the joint projects of demographers and students of urban affairs in university circles.

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Research Method in the Study of Spatial Aspects of an Economic System

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IN THE study and analysis of the objective structure and functioning of an economic system, I find neoclassical equilibrium price and production theory of limited use. In my view, this latter has developed out of social discussion of problems of economic conflict in the striving for a formulation of the attributes and behavior characteristics of a "good" or desirable mode of organizing economic activity. The nature and usefulness of this theory should never have been thought of in terms of description and prediction of actual economic behavior and development. But clearly, description and analysis of the actual performance of the economic system are implicit in any discussion of the existence of defects in and of the ways and means of improving this actual performance.

Problems of describing and analyzing the actual performance of an economic system may be considered at two distinct levels. One set of problems deals primarily and simply with estimation and tests of hypotheses. An enterprise economy is said to have certain hypothetical virtues—quantitative in nature and apart from the principal virtue of providing for the maintenance of mutuality in individual relations. There are also supposed to be certain major defects in the economic organization approximating an economy of this type; certain of the assertions of these virtues and defects may be framed as hypotheses and empirically tested. But a knowledge of methods of estimation and of tests of hypotheses is not sufficient for the resolution of contradictory beliefs regarding the quantitative results of the performance of an economic system. The meeting of minds on the truth or falsity of any such statement involves social discussion and prior consensus on just what the facts must show in order that the statement be generally accepted as true or false. Examples of such quantities involved in statements of fact are *degree of economic stability*; *degree of equality* of income distribution; *degree of competitiveness* of an economic system; *economic growth; standard of living*. There are, of course, numerous ways that may be proposed for measuring any one of these quantities, and, if all were applied to the same set of data, contradictions would appear regardless of the precision of estimates. But once a measure has been agreed upon—that is, just what to compute, given the availability of acceptable data—then the problem becomes a simple scientific one of estimation.

At the second level, one may consider problems of describing and analyzing the structure and functioning of an economic system that are quite apart from any immediate and specific topic of social discussion. Scientific inquiries at this second level seek for permanencies and uniformities that may be brought to the level of consciousness, as setting the conditions under which solutions of social problems may be worked out within a group.

It is at this level that I consider the study of the spatial aspects of an economic system to fall. The economy consists of an interdependent system of economic *units*—firms on the one hand, and families or individuals on the other. Although these units can and do move about over space, there is a marked degree of statistical stability in the spatial arrangement of the *density* of the population of

families and producing units. From the point of view that I assume, the term "economic system" brings to mind not so much the likeness of a great machine having a durable goods sector and a non-durable goods sector, or having manufacturing, agricultural, mining, and distributive segments, but rather a great expanse of territory over which are spaced population clusters. These clusters appear to be not randomly dispersed in space, but to be formed into a system of clusters (or a configuration of densities) in which size (or density) and distance apart seem to conform roughly to some undisclosed rule. A specific group of small clusters is oriented with respect to a certain larger cluster. A particular set of larger clusters, with their smaller satellites and areas of dominance, is oriented with respect to a still larger cluster. Lines of union connect the clusters, along which flows of traffic and impulses pass. High economic activity is equivalent to a high volume of economic flows within the clusters and along the lines of union.

The major part of the goods and services produced within the hinterland of one of these population concentrations never gets out of the area. On the other hand, something like a third or fourth of resources and employment of such an area is devoted to production funneled through the population center and dispersed to surrounding centers. Each primary trade center constitutes a point of dispersion as well as a point of absorption of flows of economic products. The distance traversed by these shipments seems to conform to a pattern. From what I have done and from the work of others that I have seen, I am led to give the following description:

Suppose that, for a given regional unit and time period, the final destination were known for each product or value addition produced within the area and marketed through facilities in the regional center. Then the distance from the center added to the destination for each unit of value would be a variate for which a frequency distribution could be formed. For all regions there would be a marked concentration of the distribution within the short distances. This reflects the residentiary or home-market enterprises absorbing in each region a fairly uniform proportion of the employment. The tail of the distribution, measuring the spatial extent of the market area for the "export" products, would vary from region to region. For some regions, the "export" products are restricted to relatively short distances, so that the tails of the distributions of such regions would drop off rapidly and approach zero at short distances; that is, the flow of products issuing from a given regional center and in a given direction, consisting of many items going varying distances, ultimately peters out, and for many regions this playing-out process is relatively rapid. This is perhaps the case even for many products that are thought of as nationally marketed. If the sales of specific plants producing such commodities were investigated, per capita consumption would be observed to decline markedly with distance from point of production. But the influence of distance upon per capita consumption of the various communities would be found to vary from great to slight, and at this latter extreme the tail of the region's distribution, once it had dropped off from the short modal distance, would show no systematic tendency to approach zero as distance increased, but would simply be truncated at the extreme distance determined by the bound of the entire system of regions. This condition represents what I have called *simple regional occupational structure*—a relatively large proportion of employment and resources absorbed in production locally consumed, a small proportion in production with market area not local but yet restricted to intermediate distances, and another relatively large proportion in production whose per capita consumption is not importantly affected by distance from the point of production. *Extreme simplicity* is represented by an economic community whose "exports" consist of a single product the per capita consumption of which is not affected significantly by distance from the point of production. Actually, the "exports" of a region are seldom or never confined to a single product. By and large, however, it is found that the specialization is frequently quite marked. It is also a very special case that the "export" products of a community are distributed uniformly over a nation- or system-wide market. The many economic communities organized into the system approach simplicity, in the sense referred to here, at one extreme, and at the opposite extreme are communities with many "export" products sold in markets closely restricted in space. Typically, there are for a given regional community a few major "export" products sold in markets spatially restricted in the manner described in these paragraphs.

The above constitutes a background for a formulation of a model system of interconnected economic flows. The elementary units from which the flow components emanate are constantly moving to and fro over space and are constantly dying out and being born. But a fairly high degree of stability is maintained in the group configurations and in the general population aspects of the system. The flows originating within a given concentration of firm and family units typically have destinations "close" to the concentration center, these destinations having a characteristic density pattern. The flows coming into such a concentration center are from origination points having similarly a characteristic density pattern. The interconnections between widely separated concentration centers are to some extent direct but are primarily indirect through numerous overlappings within the intervening concentration centers. By virtue of specializations and direct connections with other specialized units, some spatial groupings include disproportionate numbers of elementary units whose flows are less subject to easy management or are characterized by a systematic downward bias. The conditions under which other spatial groupings are developing may imply the reverse, so that in aggregate rises

and falls of the payment flows of many such groupings there may be in evidence a "normal" geographic ebb and flow of *stocks* of money funds.

All this is a hypothetical conception, subject as ever to revision and improvement as empirical inquiries continue. There are, of course, many possibilities of combinations of perturbations and change that would lead to cumulative or periodic developments. But these possibilities have yet to be analytically developed.

The Approach of Human Ecology to Urban Areal Research

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TO UNDERSTAND the approach of human ecology to areal research it is necessary to recognize that that point of view was developed initially by students who were primarily interested in the city and its problems. Now in the city the natural environment tends to be more or less completely replaced, as it were, by a man-made environment. Of course, as a variable in research in human behavior the one kind of environment is as natural as the other. Nevertheless, the composition of environment in the city is different from what it is elsewhere. There is one important exception to this assertion: area remains as a common denominator in the environments encountered in the open country and in the city.* Even so, however, area in the city is area stripped of its usual connotations of resources, flora, fauna, and, one is tempted to say, even climate. It is area without content, area reduced to the abstraction of space.

In the urban community, space is experienced in two related ways. In the first place, it constitutes a resistance to man's movements. To pass through it requires an expenditure of time and energy, with the result that distance enters into human relations as an important limiting and selective factor.† In the second place, space represents opportunity to carry on activity; that is, it is experienced as site location and as room to operate. It should be apparent that the conceptions of resistance and site as used in this connection are complementary. The essential virtue of site is accessibility. Unless individuals and groups have access to one another, they cannot function interdependently. Similarly, an abundance of space may count for little, if it is not appropriately located. On the other hand, accessibility varies with the resistance to movement that space presents and that, in turn, depends on the facilities for movement that a population possesses. The range of accessibility is less by pedestrian travel than by horseback and less by horseback than by mechanically powered vehicle. Accessibility differs also by type of relationship. Units involved in frequent meetings and exchanges must have a greater degree of accessibility to one another than do units whose interrelations function infrequently.

The city or, preferably, the urban community is an aggregate of interdependent units disposed about a localized area in such a way that the accessibility of one to another bears a direct relationship to the frequency of exchanges between them. Ecologists have relied largely on competition to explain that spatial order. Thus, as the concentration of population in an area exceeds the saturation point —i.e., the density at which the optimal requirements for space and accessible location of each member are satisfied—competition for position in space ensues.‡ The outcome is a distribution in which the most intensive uses of space occupy the most accessible locations, and the least intensive uses of space are relegated to the least accessible locations. E. W. Burgess has utilized this gradient conception to describe a generalized pattern of land use distribution formed of a series of concentric zones.[1] Since like units have similar location tolerance, each zone is more or less homogeneous in the characteristics of its occupants. As a refinement of zonal homogeneity Burgess incorporated the natural area conception suggested earlier by R. D. McKenzie,[2] the natural area being a more or less com-

* This is also true of time, but since time is not a subject of this symposium, it may be excluded from the present discussion.

† Even such geographic features, often found in urban areas, as bluffs, rivers, marshlands, etc., are reducible to terms of distance as measured in units of time and energy involved in crossing or circumventing them.

‡ This assumes no corresponding improvement in the facilities for overcoming the friction of space.

pact cluster of members of a given population or land use type—e.g., the Jewish ghetto, the Negro settlement, the ethnic neighborhood, the financial district, the theater district, etc. Each of the several zones may contain one or more natural areas. McKenzie subsequently elaborated upon the concentric zonal pattern, specifically in regard to the influence of transportation routes on land use distribution. He also attempted, with uncertain success, to adapt the succession concept to the development of the natural area.[3]

Many important details have been passed over in this brief résumé of one phase in the approach of human ecology to areal research. From the standpoint of theoretical development, that phase seems to have ended with the work of Burgess and McKenzie. The concepts zone and natural area were and still are widely used as classes for the sorting of various kinds of social data in correlation studies. But these applications have led to no further extension of the theory of areal structure. For the most part, individual researchers have been led into detailed analyses of specific problems of spatial relations without ever returning to a generalization of their approach, and in much of this work the analysis of spatial distributions has seemed to be an end in itself.

A somewhat different though not unrelated treatment of the areal factor was carried on largely by McKenzie. His studies of the territorial integration of regional and metropolitan populations retained the conception of distance, employed in the analysis of the urban center, utilized competition as the explanatory variable, and involved some attempt to apply the succession and dominance concepts developed in plant and animal ecology. But the main concern was in the effect of changing distance, occasioned by transportation improvements, on the interdependences between spatially separated settlements and on the growth of metropolitan centers.[4] This problem continued to attract a large volume of research effort.[5]

Running throughout the work of human ecologists on space is a hypothesis, often but faintly perceptible, though set forth early by R. E. Park in an essay on "The Urban Community as a Spatial Pattern and a Moral Order,"[6] to the effect that spatial distributions or patterns are expressive of social structure. In other words, space constitutes a dimension on which social structure can be measured. A test of this proposition presupposes a rather full knowledge of social structure; at least the essential units and their interrelations should be so clearly identified as to be readily observable. Given that, numerous corollary hypotheses are derivable, of which the following are illustrative:

Every functional component of the community, by virtue of its function, has peculiar location requirements.

Location tolerance varies inversely with specialization of function.

Improvements in transportation and communication (i.e., reductions in the frictions of space) enlarge location tolerances.

The distances separating functional units tend to vary inversely with the frequency of exchanges between them.

Problems of this order, which concern the relationship between social structure and space, occupy the center of attention in the current research of human ecologists. That they have a direct practical value to planning programs is evident. Much more empirical work is necessary, however, before satisfactory conclusions may be reached.

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Concluding Comments

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THE papers summarized here and the informal discussions of the symposium together disclosed considerable agreement among various disciplines as related to the study of urban areas. In fact, points of agreement far outweighed points of difference.

Twelve statements may be made that illustrate items on which all participants seemed to agree:

1. An urban area is something more than a formal political phenomenon, e.g., a municipality. Such areas have objective characteristics that may be studied by the use of scientific method.
2. Urban areas are highly complex.

3. The varied aspects of an urban area necessarily include (*a*) population, (*b*) physical environment, (*c*) cultural-social environment.

4. All three aspects are closely integrated so that each of them can be carefully understood only in relation to the others; and an urban area per se can be fully understood only in terms of the integration of all three.

5. An urban area cannot be adequately understood apart from a broader network of relations within which it plays a specialized part.

6. Urban areas of varying size and inclusiveness may be studied—for example, the city as a whole, subareas within the city, the city-hinterland region.

7. Both static and dynamic aspects of urban areas need to be studied, e.g., structure, function, process, change.

8. Urban areas may be studied through use of different kinds (or levels) of analysis.

9. In order to obtain full knowledge of an urban area a variety of scientific disciplines must cooperate.

10. Each discipline presumably makes distinctive contributions of its own—viewpoint, kinds of problems studied, hypotheses, concepts, methods, techniques, principles of interpretation, or collection of facts.

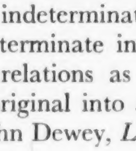
11. The distinctive contributions of each discipline presumably are useful to one or more other disciplines.

12. Problems of urban planning and control depend on integrated knowledge derived from several cooperating disciplines.

Most of the points of difference that became evident during the discussion rested on contrasting emphases rather than on contradictory points of view: Evans, a biologist, placed greater emphasis on the use of biological energy than did other participants; Vining, an economist, emphasized the city as one aspect of a system of economic production and distribution; Breese, a demographer, emphasized population factors as basic to the work of other disciplines; and Hawley, a sociologist, emphasized the influence of space as an abstraction essential to the analysis of urban spatial structure. In contrast with these points of view, each of which abstracted out some special aspect of urban areas for intensive investigation, Mayer, a geographer, and Adams, a biologist, both emphasized the necessity for integrating all aspects of urban study under a single discipline; but they disagreed as to the field which should make this complete integration, the former identifying it with geography, the latter with human ecology. Probably the closest approach to contradictory points of view occurred when Whittlesey and Mayer opposed Hawley's contention that space itself, as a conceptual abstraction, affords a basic tool for the analysis of urban areas.

In general, it is interesting to note that differences in emphasis and in point of view seem more characteristic of individual participants than of academic disciplines. For example, Evans' paper shows greater similarity to those of men from other disciplines than to the paper of Adams, who is a fellow-biologist. Similarly, the papers of Whittlesey and Mayer, both geographers, show as great a difference with respect to each other as either shows in comparison with other papers.

At the end of the discussion, all participants agreed that similar interdisciplinary programs should be held in the future. They recommended a further session centered around some narrower problem of urban areas as part of the program of Section K for December 1952.



Inquiry is the controlled or directed transformation of an indeterminate situation into one that is so determinate in the constituent distinctions and relations as to convert the elements of the original into a unified whole.
—John Dewey, *Logic: The Theory of Inquiry*

Human Adjustment to Social Law

BRUCE STEWART

Bruce Stewart writes that there is nothing in his biography "of any particular note." He has been in the Biology Department of Missouri Valley College for four years, but the work described in his paper is a small part of the program of the American Humanics Foundation, established in 1949 to give scientific human relations training to future executives in the Boy Scouts of America. He is the author of Humanics: The Scientific Method in Human Problems, *used in the course of the same name taught, of course, by Professor Stewart.*

An increasing group of lay people desires clarification of the day by day social problems, not on the basis of opinion, but on the basis of objective insight. Many of us feel that socially we are living in a fog. . . . If our social visibility could be increased, if the average citizen could see ahead farther and perceive more clearly, our social climate would change, fear and tension would diminish.

—Kurt Lewin

The core of human drives and desires and of all culturally determined purposes remains biological. Thus man, like the animal, is not free to defy the laws of nature. Nor is he free ever completely to detach himself from his organic needs. The enormous extension of freedom through culture in this respect consists primarily in the reshaping of environmental conditions and resources.

—B. Malinowski

UNDERLYING all science are the assumptions that there are processes in nature that we call natural laws and that man can discover these creative forces in his universe. A corollary to this is less often emphasized by the scientist: that man succeeds in his world only when he adjusts his ideas and his actions to these realities.

For a person comprehending gravitation, thermodynamics, and other physical processes, to frame his actions in opposition to such realities would seem to us incredible. Why does this not occur? Possible answers are that several hundred years of discipline in physical sciences have conditioned us to an objective view. We have learned that these laws will continue to operate without regard to our desires, which are usually built upon erroneous ideas. Perhaps, too, the tremendous cost of opposition is readily apparent in these cases.

The transfer of this discipline from the physical sciences to the social sciences is still very incomplete, and it is doubtful if the latter studies can be said to deserve the status accorded them by this name until they have achieved such an orientation. Nor is it likely that we shall see any systematic and permanent solutions to the grievous problems of society until those who deal with them—whether political leaders or the population at large—adjust their programs to the social forces.

With this in mind we may turn to our objectives, which are: (1) a brief consideration of the nature of some social laws, (2) an examination of some contemporary activities that seem to be in direct opposition to such laws, (3) some causes and results of this opposition, and, finally, (4) some observations on the relationship of this viewpoint to the problem of freedom in the modern world.

A law must have constancy in time and space if it is to be detected. Socially we must look for those forces in the individual and group which manifest such constancy, as otherwise we could place little reliance in them. We may begin by observing that all humans have the same fundamental physiology. Springing from this physiology are certain motivations, such as hunger, thirst, sex, other visceral states, and even the so-called derived drives. Dashiell concludes, "Tissue needs are the source of drives."

In a similar way the physiology of the central nervous system, especially the cerebral cortex, seems responsible for certain universal behavioral forces: the drive for recognition (ego) and those Murphy calls "activity drives," bringing about the function of one's structures and abilities, including not only organs or parts but rational activity and the group function. This is not the place to dilate upon the evidence and conclusions on this subject, but summaries by such men as Murphy, Klineberg, Malinowski, and a number of psychiatrists are very effective.

There is no culture that does not manifest these

drives in some form. The use of different means of expressing such innate energy has been called "canalization" by Janet and "mechanism" by Woodworth. Recognition is canalized into accumulating money, collecting scalps, labor productivity, and so on, depending on whether one is an American, a red Indian, or Russian. Attempts to suppress this energy completely result in failure and in a greatly enfeebled society. Often the results will appear in distorted and explosive forms.

It is important to explore the relationship between mechanism and drive. Each culture makes the error of assuming that its own mechanisms are the truly innate features of man. One finds this view generally in association with such phrases as "You can't change human nature." The task of the scientist is one of canalizing universal drive energy into the most socially and individually constructive forms.

The operation of these individual forces through their cultural mechanisms has produced certain group forces with a definite directional quality to their movements. We shall call these vectors. Obviously we cannot be concerned here with those numerous but localized vectors; our attention must be focused on those of great formative significance in national and international events. The technological vector is so overpowering that the others are more or less subsidiary to it: the increasing size of the social unit and the centralization in the control of social functions.

There is a constant interaction of individual drives and of these with the group forces, and this is at present recognized to be of great complexity. It is probably a rare occurrence when a course of action is satisfying (or frustrating) to all the needs of a person or cultural unit. Such conflict of forces, if serious and sustained, brings about neurotic symptoms in both individual and group. Obviously, however, there are adjustments that are largely satisfying and those that are almost completely inadequate, and it is the goal of the scientist to achieve the former on every social level.

This by no means completes the list of determinants, but it is at least sufficient for some preliminary conclusions and it will enable us to illustrate the objectives already established. Each of the following sections is organized around a general principle derived from the realities here outlined. Since concepts only develop meaning as they become clothed with specific experience, reference will be made to several recent books on current events, by experienced and fearless reporters which seem to approximate the present approach.

I. Any Institution Succeeds or Fails in Proportion to its Degree of Satisfaction or Frustration of Human Drives

Political, economic, religious, and other social institutions have succeeded or disappeared in the past on the basis of how they functioned as mechanisms of drive satisfaction. The psychiatrist Fromm[2] observes:

> The influence of any doctrine or idea depends on the extent to which it appeals to psychic needs in the character structure of those to whom it is addressed. Only if the idea answers powerful psychological needs of certain social groups will it become a potent force in history.

It follows that any individual or group that becomes identified with what appears as a drive-frustrating policy or institution will receive a strong negative reaction. Smith, Stowe, Belden, and others have shown by a wealth of firsthand observations how America has both identified itself, and been identified propagandistically by the Russians, with efforts to preserve and strengthen regimes that were disintegrating because of their frustration program—Spain, China, and certain other nations of Europe and Asia.

UNRRA, the Marshall Plan, CARE, and similar efforts have in a measure acted as counterforces, but, to judge from the temper of foreign peoples generally, the result has been in the opposite direction. The explanation for this phenomenon, aside from simple ignorance, might be that such people hold their own efforts at helping themselves and solving their own problems to be more important and valuable than external gifts and assistance, especially if used coercively. It seems probable that the American ego would react very much in the same fashion were it in the same situation.

Sternberg[3] points out the danger of an American policy that thwarts social change in European nations, which is necessary to integrate a successful operating system under changed circumstances. Even though we may disagree with these changes, such intervention is opposed to the driving forces of both the individual and of European culture (as will later be shown). The Russians are capitalizing on this need in Iran, Indo-China, etc., where we are losing ground.

To what extent can one substitute propaganda for reality with respect to our orientation toward or against institutions as regards their satisfaction or frustration of drive? This is a significant question that cannot be explored here, but a few observations may be justified.

Our thinking has too long been dominated by mere approval or disapproval of social concepts, without reference to the realities that sustain or

defeat them. The past furnishes many illustrations of how changes have been compelled when frustration becomes intolerable for those involved. The revolutionary phenomena (French, Russian, Chinese) are the result of extreme and unmitigated frustration. The evolution of English democracy shows numerous compromises and concessions that relieved social pressures. The rise and decline of empires such as the Roman may be correlated with such policies.

Popular judgment is based on the formal control of a nation rather than whether this administrative form is solidly anchored in the need satisfaction of its constituents. There are, therefore, limits on governmental forms, and the common belief that an unrelieved oppression may be developed and sustained indefinitely seems untenable in the light of this interpretation. A related error is the belief that we can compensate for this type of mistake with military success. Simple cause-and-effect relationships in problems of this nature are obscured by a great number of factors, and the effects of social malpractice can be deferred and modified, but the macroscopic changes seem clear enough in their general pattern.

The naïve view that a failing institution is always replaced with one superior in every detail is also clearly untenable. Especially is this true of revolutions where social excesses flourish in the destruction of the machinery of balance and compromise. Even here there is generally an improvement in the specific frustration pattern which gave rise to the upheaval, and, again, viewed macroscopically, an irregular progress is apparent.

II. Visceral Drives Tend to Take Precedence over Activity Drives and Both over Cognitive Functions

Although there appears to be no rigid hierachy of drives, there is a fairly constant relationship between visceral and activity drives and between both these and cognitive functions. During great starvation the organism is unable to respond to stimuli that would normally evoke activity and even other visceral needs. This was observed typically among European and Asiatic victims of starvation and in the controlled experiments on starvation conducted at the University of Minnesota by Keys, Brožek, and others.[4] In all cases the prominence of activity drives for bodily movement, thought, expression of individual abilities, even sexual interest, virtually disappeared. Under this emergency physiology the individual was incapable of giving sustained and effective attention to anything but food. Thresholds for all other activities became extremely high.

This provides a reliable basis for understanding why Russian appeal has been more successful than ours in many areas of Europe and Asia. Smith[5] concludes that America in all-too-many cases is playing the role of identifying itself with frustration of more basic needs, whereas the Russians represent frustration of the more secondary activity drives. Smith observes:

> They [the Russians] have brought to eastern Europe certainly a richer life for the common man. If they have not given him freedom by Western standards they have created the only basis on which freedom can one day be won: by breaking the shackles of the hideous poverty and ignorance of the isolated Eastern countryside and providing new dimensions for human development among those backward people.

The precedence of certain activity and visceral drives over the process of knowing is called autism. Murphy[6] defines it as "movement of cognitive processes in the direction of need satisfaction." Common observation will supply many illustrations of how we are unable to follow a course we know to be right intellectually if a different course appears to lead toward immediate satisfaction of basic needs.

An interesting illustration of the dominance of needs over content is given by Smith[7] from his study of eastern Europe:

> Throughout the countryside of the East, community centers and schools have mushroomed and added no little enrichment to a way of life that before the war was merely barren and oppressive. The purpose, of course, is to propagate Marxism. But to the rural paupers so long neglected, it would make no difference if the aim were to instill Confucianism, so long as it is a show of interest in them at last, and evidence of at least sufficient respect for their opinions to try to influence them.

Freedom (the expression of activity drives) can only emerge when basic visceral tensions are reasonably well satisfied. The greater the starvation, the more susceptibility to totalitarian and antisocial doctrines and practices. Lasswell demonstrated how the increase in communism in America correlated decisively with the increase in the depth of depression and unemployment. It is not necessary to comment further upon the implications of such evidence.

III. Thresholds for the Expression of Drives Affected by Cultural Conditioning

It has been commonly concluded that different cultures of people in the world have totally different, and generally inferior, motivating forces because they seem so well adjusted to lower material and cultural levels than the people of Europe and America. Yet when any of these people are reconditioned to the mechanisms of drive expres-

sion found in the Western world they react indistinguishably from Americans.

Martin Johnson commented on the fact that the African Negro was unimpressed by his expedition's wonderful mechanical equipment, being thoroughly conditioned by their culture to different canalizations. Negroes who earlier were brought to America as slaves maintained for a considerable period their simpler mechanisms of drive satisfaction. When they replaced these with Western mechanisms (as unconsciously encouraged to do by Caucasians), they became less well adjusted and came more into conflict with the Caucasians.

Having taken on the same mechanisms, the thresholds for drive expression in these terms were steadily lowered by increasing opportunity to compare their level of satisfaction with others around them. It would seem a safe conclusion that the amount of maladjustment and tension is proportional to (1) the difference in canalizations and, these being similar, (2) the degree of ignorance of the different satisfaction levels.

One cannot fail to be amazed at the toleration of the Chinese peasants for the magnitude of their frustrations in the incredible corruption of the Kuomintang government. Apparently the reaction was delayed because of the absence of higher standards for comparison and a long conditioning of acceptance. Even this had its limits, however, as Belden has shown, and only on this basis can the surprising events of the Chinese revolution be comprehended.

John Fischer[8] makes similar observations about the cultural conditioning of Russian peasants. Many of their attitudes toward their present rulers and toward freedom cannot be understood in the context of the Western world. Sternberg shows that the hierarchy dares not allow the comparison of satisfaction levels to be made that would result from broad contacts with the West if the present adjustment is to continue successful.

In the modern world of expanding technology, with transportation and communication bringing populations into ever-closer association with each other, it becomes correspondingly more difficult to maintain complete ignorance of such comparisons. The results of this increasing awareness were concisely stated by General George C. Marshall in a speech at Honolulu:

> There is no doubt in my mind that we are in the middle of a world revolution—and I don't mean Communism. The communists are like your surf-riders here; they're just moving in on the crest of a wave. The revolution I'm talking about is that of the little people all over the world. They're beginning to learn what there is in life and to learn what they are missing.

It is instructive to note that this struggle for equality of satisfaction is the same mechanism that resulted from Western man's successful efforts to manifest his superiority by possession of such mechanisms of satisfying his needs. This in turn was made possible by the technological vector, the main effects of which we must now inspect.

IV. The Technological Vector Compels Greater Social Integration on the International Level

From the foregoing it should be plain that the growth of technology is bringing all peoples into closer association with each other. This has resulted in (1) a greater similarity of drive mechanisms, (2) greater opportunities to compare satisfaction levels, and (3) heightened conflict because of the perseverance of mind-sets of difference and inferiority growing out of the old cultural isolation.

Modern technology has been achieved only by increasing the degree of cooperation between individuals and groups. The examination of many world cultures contained in Mead's *Cooperation and Competition*[9] gives rise to the following:

> The positive correlation that exists between the complexity of technology and cooperation in production is obvious. Where productive techniques have been at all ingeniously contrived, the division of labor has necessarily been intricate and since the division of labor in a single enterprise by definition implies cooperation there can be no doubt that the nature of technology and cooperation in production are closely associated.

In this way cooperation has been elevated above competition on the international level. Concomitant with this there has been an increase in the size of the social unit, for which the growth of technology from the most primitive times has been responsible in large part. Increase in the scale of social organization has regularly lagged behind technological realities, and the former process has been accomplished largely against the wishes of people.

Since the very inception of the Industrial Revolution there has been a conscious effort to avoid the growing entanglements of groups and nations, which was implicit in the industrial society. There has been a persistent adherence to earlier patterns of competition and complete individualism on the part of the people belonging to the archaic group (now called nationalism). But the kind of problems that arise transcend national boundaries, and they are the hard kind of necessities that cannot be put off. Consequently there have grown up economic units called cartels, which have been the inevitable result of the necessity of dealing with the economic "One World." Though their utilization of power is sometimes appalling, they can only disappear when replaced by more effective institutions that

perform the same functions. National independence of action has steadily succumbed to interdependence as specialization has increased and operations have grown in complexity (*cf.* the Schumann Plan).

Nations have been more or less free of restraints and organization, but this is a source of fear and suffering for most people, so that although they may persevere in nationalistic feelings they tremble at the prospect of where such conflict and struggle clearly lead. This fear has been a fertile source of mass neurosis and escape activity.

As a breakdown of the system becomes more intolerable, opposition to international integration will sooner or later be circumvented, whether through intelligent design or totalitarian unity. Use of the machine will continue and even accelerate its spread over the earth and in doing so will intensify the necessities of the technological vector.

V. The Technological Vector Compels Greater Integration on the National Level

Those nations and parts of nations in which a frontier has been dominant are highly individualistic because of this cultural fact. Competition is thought to predominate over cooperation, and independence is extolled above interdependence. This adjustment to circumstances is generally successful, not only for the agricultural period but even during the first stages of the Industrial Revolution. As industrialism advances, the necessity for social integration increases sharply. Independence of action in its old form becomes more intolerable, since the amount of disruption resulting from unintegrated acts is proportional to the degree of specialization.

The history of highly industrialized countries provides many illustrations of the growth of integration under conditions of necessity. England is typical, since it has no domestic frontier and has progressively lost its colonial frontier. It is also selected because of its ability to carry on such integration without marked loss of mechanisms of individual drive satisfaction. This phenomenon of advanced industrialism—what Smith calls a loss of "slack for social compromise"—has made it inevitable that planning for integration should be increased.

It is only within such a framework that the socialization policy can be understood. When Sankey, Churchill, Heyworth, and other leading Tories recommended the nationalization of coal, railways, gas, etc., it was a considerable shock to many Americans. Yet, as one of them said when questioned, it was the only thing that could be done. Cowles[10] and Hurwitz[11] have made revealing studies of socialization activities in England.

Careful examination of every industrialized nation will disclose examples of increasing integration in one form or another. Even the United States shows some interesting symptoms. During the years 1929–32 the Republican administration was compelled slowly but steadily to relinquish its doctrine of complete individualism and undertake certain programs of integrated attack. Mitchell[12] has given an excellent and documented account of this transition and summarizes it as follows:

> Roosevelt in his first campaign was not so far ahead of Hoover, in the seriousness of his apprehensions or the boldness of his proposals, as his later policies imply. Nor was Hoover's reaction to the depression all of a piece. Reluctantly but steadily, as forced by circumstances, he departed from his predilections, devising numerous government aids to recovery. As more or less developed, not a few of these were patterned after by the New Deal.

It is very significant that such changes in outlook on the part of both electorate and administration occur during times of crisis. The velocity of social change is strongly correlated with frustration of drive expression. This is not to say that the change will invariably be in the best possible direction, but if it does succeed (at least apparently) in greater drive satisfaction then it will persevere. Welfarism in the United States originated and is sustained for this reason and not because of the personal desires of any one administrator or group. The fact that it persists so strongly into times of prosperity is indicative of its deep impression.

All this has led to the development of a striking autism in the American people. One manifestation of this was in the Link Psychological Barometer Poll of December 1949, which showed that 75 per cent of adults questioned in 137 cities were "against socialism in America." At the same time, a majority of those questioned favored TVA and other such authorities, government housing projects, and taxes for security benefits, although they recognized that these were a part of the socialistic program. The basic needs definitely took precedence over cognitive functions.

It would seem safe to conclude that mere verbal persuasion and propaganda lose effectiveness when they involve ideas that are operational and fit need structure of real experience. When the most vociferous advocate of *laissez faire* will accept government aid if it fits his particular need, then it is naïve to keep on assuming a condition of pure competition and individualism. A recent illustration of this was the case of Senator Brewster and the potato subsidy. It was profoundly meaningful that the Senate Agricultural Committee told the Secretary of Agriculture that the potato surplus was "an executive problem."

Belden's[13] description of the "land problem" in China shows that similar coercive realities have compelled the Chinese to put the group above the individual.

What, then, will prevent this increase in social integration and planning from leading inevitably to despotism? To answer this question we must consider the fact that:

VI. The Centralization Vector Points to a Change in Control Concepts

The transition from a frontier, poorly organized culture to a populous, integrated industrialism has produced a centralization in social functions. This is seen in government structure, in capital and labor structure, and in many other institutions. Only a brief mention can be made of the causes.

1. Greater complexity and increasing magnitude of problems discourage participation by the average citizen, demanding more information and facilities than he commands. Consequently he is only too ready to leave such matters to "someone who knows more about it," sometimes without much respect to whether such person does or not. Any large-scale organization will show such manifestations.

2. Economically, uncontrolled, individualistic competition has a built-in pattern of success and failure. The more efficient competitor who produces better succeeds and grows larger, often by absorption of less effective contestants. The over-all trend is toward a continuing reduction in the number of businesses, and increasing size and power of the ones that succeed.

3. Enterprises depend more and more upon research facilities and discoveries made. Maintenance of expensive laboratories is possible only to larger concerns, resulting in a concentration of benefits and control of discoveries, and therefore at least an advantage in the industries based on them.

An opinion is prevalent that large-scale industry is democratic because of its several hundred thousand stockholders. This error is based on the assumption that ownership and control are identical. Control is generally held with a very small percentage of the voting stock, as was shown conclusively by the TNEC investigations. Apologists are as much out of place here as are critics, since objective analysis shows that such concentration of industrial control was an inevitable process.

The danger of large-scale industrial concentration to drive-satisfaction is not in size alone, or even in the fact that it may be monopolistic. Functions such as telephone service can be effective only as monopolies. The chief danger lies in the ease with which the power here concentrated may be used in socially destructive ways, even inadvertently.

Stowe, Brady, and others have described with detailed and firsthand accounts how this power was used to institute totalitarianism in Germany and Italy. It is of course true that in American there is more democratic conditioning, but Stowe[15] regretfully observes, "I met a good many American industrialists, exporters and the like who felt the same way. Their profit motives quite obscured their professed political and humanitarian principles." Certainly here is a dangerous autism.

The real question to be answered, whether in regard to private or public concentration of power, is: What assurance is there that such power will be used to satisfy human drives rather than contribute to their wholesale frustration? This question has been chronic in human history, but its significance has recently become critical. One answer has been kept alive by a host of men (Rousseau, Jefferson, Dewey, *et al.*) and by certain nations. Such humanitarians hold that control must rest in the hands of the people, since they themselves are the only ones who will look after their interests.

Democracy is a mechanism of satisfying need, a kind of assurance that power will be used in the interests of the population. Although cumbersome, it has been fairly effective in channeling power toward the welfare of people without violent changes. Its effectiveness, however, is diminishing, and it will be replaced at least in part by new, emergent, technological factors.

Another answer to the question was given in preindustrial days by Machiavelli and, more recently by others such as Pareto and, currently, by James Burnham. These assert that what has been said above is wishful thinking. Hard reality shows the inadequacy of democratic notions; especially is this true in the complex technological society. The leader is inevitable, power becomes concentrated without reference to our attempts at stopping it. The most recent exposition of this viewpoint is to be found in Burnham's *Managerial Revolution*. This interpretation, although not entirely correct, contains as much truth for the future as the democratic answer, and it is only through scientific analysis that the elements of accuracy can be identified and developed. One is apt to make the error of attributing to early writers an acquaintance with technological problems.

Veblen's engineers are easily visible in Burnham's description. Implicit also is the Veblenian idea that the industrial organism has certain necessities that man cannot ignore—that it is these forces that will compel any manager to keep it functioning. It only remains then to show a necessary connection

between these technological forces and the satisfaction of popular drives.

The only way in which a mass-production technology can be kept in operation is to make it consumer-centered, and in many instances this will be found to be in opposition to its being profit-centered. Depressions are the result, not of overproduction, but of underconsumption and of the destruction of purchasing power. We have begun to learn that produce is of little value unless it can be consumed. This is equivalent to economic functioning to satisfy human drives; in fact, this is the only way in which the system can be kept operating, though it may take us some time to discover it.

It is not difficult to see how the denial of constructive expression of the activity drives would disrupt an effective and continuing adjustment to the technological process. The question of freedom, however, demands closer scrutiny in the light of what has gone before.

VII. Freedom—The Adjustment that Permits Maximum Drive Expression by the Total Population

The centralization process and the weakening of the democratic mechanism are viewed with great alarm on every side by honest conservatives and honest liberals alike. Both feel that freedom is menaced and liable to become extinct. Books such as George Orwell's *1984* paint a fearful picture of the disappearance of freedom from the all-powerful centralized state, set in the midst of superwars, supernationalism and international competition, the outcome of which is extinction.

Before attempting any analysis of freedom, it will be necessary to decide what the essence of freedom is as a part of the framework developed here. If we inquire what it is about freedom that we value, we may think of it as the opportunity of each to do as he pleases in a human struggle. An interpretation such as this is unquestionably on the road to disappearance. A more probable interpretation is the opportunity to express one's own unique activity drives to the greatest possible extent consistent with such expression by others. Malinowski[16] corroborates this definition in his posthumous work on the subject.

> We see here that freedom consists in obedience to the constraint of drives and to the natural laws of the environment to which the animal is adapted. . . . By this we mean the individual's right to use his natural gifts as well as his trained skills and services.

In this case there is no reason to fear the demise of freedom, since any institution that frustrates it would not long survive. Nor could the group succeed that had a policy of self-satisfaction of drives at the expense of the majority. The managerial society must, when successful, preserve and even enlarge opportunities for such expression. As Murphy points out, we can develop any number of canalizations, and our error has certainly been in depending too much upon certain traditional ones. Laidler[17] has provided a stimulating treatment of new and successful incentives—that is to say, canalizations—that are now being developed.

The dichotomy that many writers believe to exist between freedom and security, when examined in this light, is unreal. Limitations on legitimate freedom now existing result from the distortions associated with the emergence of a new social form. Such deficiencies can and will be eliminated. One excellent example of how this can be done is the recent report of the Hoover Commission on government reorganization.

True freedom has become a more difficult problem than it has ever been before because of the new and demanding conditions under which we face it, but the process of adjusting the needs of the individual organism to the needs of society will be reasonably attained before the managerial society is realized.

Shaffer[18] comes to the conclusion that the only successful adjustment is to be found in the most complete satisfaction of all our motives. Since man is by nature a social creature, this adjustment will not be successful for the individual or society unless "it is achieved with consideration for the adjustments of other persons."

VIII. Human Efficiency Achieved only through Working in Harmony with the Forces of the Organism and Culture

It is deceptively easy to agree with the proposition that every individual has similar physiological and psychological necessities that must be satisfied for effective functioning, both individually and collectively. For the scientist, however, real meaning does not enter until a principle is used operationally, and it is only by this means that we can compare it to reality and to the ideas we hold. For this reason it will be instructive to apply it specifically in diagnosis and in the prognosis for (1) what is probable and (2) what would be most successful.

Historically, the scientist has waged a long and continuing battle for the objective attitude—that human malfunctioning, whether physiological or psychological, can only be dealt with successfully by identification of causal forces and an attack on these rather than on the person himself. We have overcome the primitive attitude in the field of medicine, where we no longer torment and condemn the in-

dividual who has a disease. The physician recognizes that only through contact and working with the victim can a cure be effected. In criminology and psychiatry we have begun to renounce personal attacks, ostracism, and emotional condemnation—which only intensify the problem—in favor of therapeutically working with the victim.

National and international policy will eventually achieve such an orientation, although at the present time it is a very long way from it. As illustration of this fact we may consider an emotionally supercharged issue such as Russian-American relations (not without the peril of being misconstrued). The emotionality surrounding this question is in itself good evidence of the absence of science.

The Russian revolution was the result of what many Russians thought would replace the frustration of Czarist tyranny with greater need satisfaction. Our disapproval showed itself in a futile effort to deny diplomatic recognition to a cultural reality, in attempted invasion and conquest, and in strenuous efforts to ostracize, condemn, and frustrate the Russians and their program. If we assume that they were entirely wrong in their conclusions and acts, then the objective approach would demand a great *increase* in our contact with them and an educational effort that would not condemn or frustrate but help them to achieve satisfaction while maintaining good relationships. Certainly the destruction of such good will could be expected to accomplish very little.

A recent article[19] by a top-ranking military leader gave a revealing description of how such antagonisms and conflict built up in just this fashion. When the German General Karl Wolff wished to surrender to the Americans, the question arose as to whether the Russians should be present. Admiral Leahy admitted that it was of no great consequence since in event of their disagreement they could be ignored. The decision was to bar them from the surrender proceedings. The article makes it clear how retaliatory and antagonistic behavior increased, although assuming all the while that our decision had nothing to do with it whatever.

If it be charged (correctly) that Russian leaders would not cooperate in such therapeutic measures at this stage, then the only answer is that the early physicians who could get little cooperation in scientific antidisease measures did not therefore cease their activities entirely.

This is presented to show that Russian hostility and oppression have been due in part to errors in our own policy. Fear of isolation and encirclement, of failure, of blows at national prestige from a hostile world, have caused them to become ever more oppressive in what they believe to be security measures. It goes without saying that should they continue to accentuate this frustration pattern with their own constituents, they will defeat their theoretical aims. Criticism is the essence of science and its suppression in Russia will seriously weaken that nation.

Similarly the Chinese revolution was only possible insofar as it appealed to serious need frustration of the peasant majority. Withholding recognition will fail to accomplish any politically constructive effect and will only succeed in diminishing our opportunities to work with and rehabilitate the people of China, and in animosities that bode ill for the future. The repetition of our mistakes is helping China go the way of Russia.

This analysis has assumed that the changes in Russia and China are all for the bad. As bad as many of them are, it would be difficult to support such an assumption. We must dispel the black-white stereotype that dominates the thinking of leaders on both sides. News commentators are all too eager to conform to this stereotype. An illustration of this is the case of Smith and Bender, U. S. airmen forced down in North China and held by the Chinese Communists. Contrary to advance notice, they not only reported being well treated but stated their conclusions about the superiority of the new regime over the Kuomintang. The press promptly lost all interest.

It should be kept in mind that this has been presented as what *should* be done if success is to be achieved, which must be distinguished from what will probably occur. The determinants for these two events are quite different.

Despite the obvious futility of opposition to social and organic forces, a large part of human endeavor has been diverted toward such obstruction. The effects of these endeavors have been at best a degree of confusion and distortion of social forms and at worst conflicts costing millions of lives and billions of dollars. The effects on behavior are readily apparent.

Neurotic behavior is as real in groups as in individuals. When such masses of people see their actions (or actions in their behalf) producing opposite effects to those desired, failure to solve problems resulting in further frustrations, then neurotic symptoms result, fears increase, and efficiency declines. If this pattern continues, intensifies, and involves large parts of the world, then group suicide becomes as real a possibility as individual suicide.

An objection may be advanced that this analysis is theoretical, yet there is nothing quite so practical as a working hypothesis that produces results, that

is based on realities, and that functions universally in fundamental human processes, rather than from one's own circumscribed culture.

Another objection will certainly be made that democracy is more effective than has been here described. Perhaps one of the most telling facts on this score is the absence of sufficient accurate information on the part of the electorate to permit informed judgments—the very heart of democracy. Much highly significant information has been drawn upon in this discussion, yet it is almost unknown. No more dispassionate and yet authoritative observation has been made of the reasons for this than the following statement by William Allen White:[20]

> The merchandising of news for a long while to come will be affected as it is now with a strong property interest. It will require machinery to assemble the news. It will require capital to distribute the news. And the capital today or tomorrow always has a lively sense of its advantage. . . . The sense of property goes thrilling down the line [of press employees]. It produces a slant and a bias that in time becomes—unconsciously and probably in all honesty—a prejudice against any man or any thing or any cause that seriously affects the right, title or interest of all other capital however invested.

This is an admirable statement of the autism that dominates the press and that prevents a completely accurate picture from being presented. It is doubtful, however, that most people have any desire to become involved in such complexities, and they now seem more than ever bent upon escaping them.

It may be thought that this is advocating "socialism," but there is danger in the acceptance of any set formula of this sort: The question of advocacy is largely irrelevant to the type of analysis described here. Increasing integration is inevitable. The stimulus of a clearer picture of how and why may help us channel it into a more effective adjustment with the human drives.

It may properly be objected that there is little one can do to improve the circumstances with such massive forces at work; that such behavior patterns as appear in war, race conflict, depression, and the like will change or disappear only in a different setting where the forces operate to change or extinguish them. The nature of determinism and how it applies to such instituional changes has been examined elsewhere.[21]

There has been a generalized progress in human history in drive satisfaction, but this has not been a rationally planned evolution. It has rather been Veblen's[22] evolution through desperation. In his words:

> The evolution of society is substantially a process of mental adaptation on the part of individuals under the stress of circumstances which will no longer tolerate habits of thought formed under and conforming to a different set of circumstances in the past.

Rationality (dominance of the cerebral activity drive) seems to be on a very long-term increase. A great step forward will be taken when we are able to analyze and approach large-scale human actions as conforming to an intelligible pattern and renounce emotional condemnation of such actions.

We have dealt with social problems on the basis of opinion, as Lewin remarked in the opening quotation. This framework is one of personal desire, and when personal desires are counter to the forces in society (as they often are) then actions based on them are little but a waste of energy. That this entire approach is nondefinitive is readily apparent to the higher strata of public opinion. It will be long before any appreciable number of people would no sooner attempt to thwart social forces than they would oppose the law of gravitation by jumping from a flying plane without having made adjustments for this acting force.

Until this situation prevails, the analysis and prognosis of events must be based on factors of a much lower order.

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SCIENCE ON THE MARCH

EXPERIENCES WITH ESPERANTO

THERE are few subjects offered for the consideration of the American public that have been more greatly distorted, in one way and another, than the subject of international languages in general and of Esperanto in particular. One of today's great mysteries is the prevalence of such a great lack of knowledge on this particular subject. Perhaps it is partly owing to the nation's history of isolation that this is true—and perhaps to a lesser extent the cause has been our inborn feeling that we are above such things and do not need the aid that could be supplied by a common auxiliary language. Some feeling of indifference, or active hostility, toward it may derive from knowledge of the fact that it is a so-called artificial, or synthetic, language. In reading Esperanto, however, one does not have the feeling that it is a synthetic language. It is capable of standing on its own feet, and, in recent years, the necessity of rising to its defense whenever it is attacked is gradually disappearing, as, indeed, one does not feel impelled to defend English whenever it is criticized.

My experience with Esperanto began in 1917 during my second year in high school. Within seven months, alone, and in my spare time, I had learned the language well enough to begin correspondence by its means. This ease of acquirement was due to these facts concerning it:

1) A great number of the words are similar to those of English.

2) There is only one system of verb conjugation to be remembered.

3) There is only one system of noun and pronoun declension, which provides, and wisely, I think, for only one special case termination, that for the accusative. The other cases are all formed, as many are in English, by prepositions.

4) The language is entirely phonetic, and thus spelling is not a problem.

During the twenties and thirties I obtained much practice through correspondence with persons in many foreign countries. During this period I had numerous occasions to listen to speeches in Esperanto and to write a number of popular articles in it on various aspects of science. At this point the general reader may ask two questions: First, how does Esperanto serve as a conversational and lecturing language when many different nationalities are involved? Second, can one express his opinions as well as in his native language? As for the first, it is probably sufficient to state that, learning the language by oneself and from books only, one can understand the spoken language without difficulty. I shall always remember the first lecture that I heard in Esperanto, and my surprise at being able to follow it all quite well. The lectures I attended during this period were usually given by visiting Europeans—occasionally by Japanese. The subjects covered were quite general. I personally have not experienced any difficulties in writing the language, but a true appraisal of the quality of the writing should be made by others. Another question that is reasonably common is, "What happens when a succession of speakers of various nationalities follow one another on the platform; is not a considerable readjustment necessary to cope with the different ways in which the language is spoken?" In all cases where the speaker can be considered as having a good knowledge of Esperanto, it is much more difficult to distinguish his nationality through his use of Esperanto than through his use of English. For some reason, shortly after learning the language, one falls into a so-called Esperanto style, as though the language were indeed a national language having a considerable literature to act as ballast. The many books I have read have never been obviously distinguished from one another by the nationality of the author. I am unable to guess the author's country by reading his writing. It should be added here that there is a great deal of satisfaction to be gained through the rather easily acquired ability to read original works in Esperanto, as well as the many that have been translated into Esperanto but not into English.

The literature of Esperanto is surprisingly extensive. There are hundreds of books available, many of which are original works. At the present moment I cannot say how many magazines are published in Esperanto, but I know that before World War II there were more than a hundred with international circulation. Some of these magazines could easily compete in quality, etc., with the better ones of the United States. I have in mind particularly the one entitled *Literary World*, which was published in Germany.

In the field of science, where I consider the need of such a language is greatest, there has always been a reluctance on the part of Americans to consider the matter, doubtless because in this country we

have not experienced the great need for an auxiliary language that exists in European countries, with their many and varied languages in comparatively small geographical areas. Europe in general, and Japan, have been the greatest promoters of the use of an international language, and this promotion has been in three directions—some publication of articles directly in Esperanto, the use of résumés, and the preparation of suitable technical dictionaries. Some years ago a very good technical dictionary in six languages was published, in which one of the languages was Esperanto. This is the *International Electrotechnical Vocabulary,* published for the International Electrotechnical Commission by the Comité Electrotechnique Français (1938). The I.S.A.E. (International Scientific Association of Esperantists) is carrying on the development of technical vocabularies, and it publishes a quarterly bulletin with all articles in Esperanto. Its *Review of Science* is printed in Holland, but the officers of the group live in several different countries. To the members of this association there no longer exists the so-called language problem which is of so much concern to the groups like the United Nations.

An "Esperanto Congress," held each year when not prevented by world wars, is attended by delegates from a great number of countries. For these congresses there is only one official language. The attendance has varied from a minimum of 163 in the United States during the first world war to a maximum of 3,400 at the one held in Vienna in 1924.

In concluding this short résumé, I am inclined to express the opinion that the use of Esperanto as an auxiliary language should be given more serious attention by scientific workers in our country. This opinion is based on a rather long acquaintance with the language itself, some knowledge of a few of its more ambitious prewar competitors, and on a slight knowledge of three or four national languages. As in many things, one's own personal reaction is the final test. All that the groups that promote the use of Esperanto can expect is that the newcomer will approach the general problem with an open mind.

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THE THEORY OF BREAK-IN

THE surfaces of parts finished with modern production tools are much smoother microscopically than in years gone by. It is still, however, and probably always will be, considered good practice to "break in" rubbing surfaces. A few remaining high spots must be worn down, and clearances must be worn in, for smooth operation, reduced friction, and proper lubrication. The break-in period is one of those necessary measures—almost universally accepted without argument or explanation. These few paragraphs offer a fundamental explanation of the mechanics of break-in.

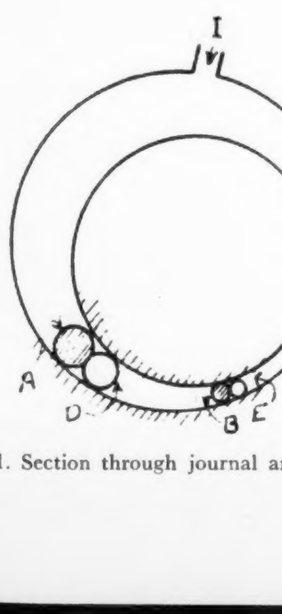

FIG. 1. Section through journal and bearing.

In Figure 1, a section through a journal and bearing, oil enters at *I* in the region of minimum film pressure. As the oil is carried down into the region of nearest approach the oil film pressure increases. This is essentially a polytropic compression in which compression and internal friction increase the oil temperature an estimated 70° F. For convenience the compression process may be illustrated by successive positions of an "overgrown" oil molecule, which occupies the space between the journal and bearing. As the oil molecule is rolled from *A* into the narrow space at *B,* the squeezing and friction will generate heat to raise the temperature of the molecule momentarily. With an oil inlet temperature of 250° F at *I,* the temperature at *B* is no less than 320° F, which is high enough to start rapid breakdown of the oil molecule.

Considerable air is whipped into the oil in the crankcase. It can therefore be assumed that an air molecule, as at *D,* is rolled into the region of minimum film thickness at *E* along with the oil molecule. The air molecule is also squeezed polytropically, with a corresponding rise in temperature—a condition that is most favorable to oxidation.

This is not all, however. Figure 2 shows an en-

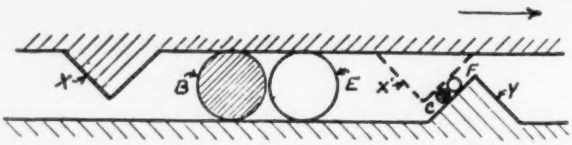

FIG. 2. Enlarged view of region of nearest approach.

larged section of the region of nearest approach of journal and bearing. There is a high spot x on the journal that was not smoothed down in the final machining operations. There is another high spot y on the bearing. If dry friction is assumed, then as x moves to the x^1 position, metal-to-metal contact will be made with an enormous increase in friction and temperature as x trys to climb over y. Result: abrasion wear of the high spots. As dry friction is an improbable assumption, however, especially if there is any pretense at lubrication, it is much more logical to assume that the oil and air molecules C and F are squeezed into this space as x^1 climbs over y. The oil and air molecules for a moment must support the entire weight of the journal. The temperature of the oil molecule, heated by compression and friction in the presence of air, will for a moment be very high. This extreme condition favors even more rapid oxidation of the oil.

The oil molecule is a hydrocarbon. Under the above-mentioned conditions it quickly breaks down into violently corrosive peroxides and organic acids.* As the acid is in intimate contact with the metal at x^1 and y, a bit of metal is quickly eaten away and passes into solution or colloidal suspension in the oil. Thus the high spots on a journal and its bearing are removed by corrosion, a process in which the lubricating oil plays an important part.

The corrosion must not be allowed to continue indefinitely, for then the bearings become pitted, and serious damage will result. The oil quickly becomes contaminated with oil breakdown products and with metal in solution or colloidal suspension. For this reason the first fill of a light break-in oil in a new engine should be drained after a few hundred miles. Once the high spots on the rubbing surfaces are removed, a heavier oil, which is a little more stable than the break-in oil, must be used. The problem of oil breakdown and oil corrosion does not disappear with the use of a heavier oil, however. It can be minimized only by sufficiently frequent oil changes or by the addition of corrosion inhibitors, which are reasonably effective only insofar as they in themselves remain stable.

There are some break-in oils and some oil additions on the market that are supposed, among other things, to reduce friction. Some of these additions are known to be highly corrosive even at room temperature. With these, breaking-in becomes an accentuated corrosion process, which continues at a rapid rate even after the high spots are removed. Break-in corrosion may be tolerated only if corrosion can be stopped at the right time.

The break-in procedure must be looked upon as a final finishing process—a sort of electrolytic-polishing. It must never be construed as a cure for poor machining practices; nor is there any excuse for the addition of corrosive agents to a break-in oil. A good break-in oil and a good lubricating oil in themselves are noncorrosive. It must be *particularly emphasized* that corrosive properties which come into legitimate play in break-in are those that develop momentarily at high temperature points as a result of breakdown of a few oil molecules at a time.

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* Weiland, W. F. *Sci. Monthly*, **71**, 121 (1950).

NEW MAPS

WHEN finished the National Topographic Atlas of the U. S. Geological Survey will cover nearly the entire nation with large-scale mapping in accordance with current national map accuracy standards. Among maps available are the following:

National Park Maps

Black Canyon of the Gunnison National Monument, Colorado. Scale, 1: 24,000; contour interval, 40 feet. Single sheet contour ed., 20 cents; shaded relief ed., 35 cents.

Black Canyon and the surrounding area were established as a national monument by Presidential proclamation of March 2, 1933. Within its boundaries lies the deepest and most spectacular 10-mile section of Gunnison River's dark, formidable gorge. The gap from North Rim to South Rim at this very steep place is 1,100 feet wide and 1,700 feet deep. The river below is scarcely 40 feet wide—slightly more during flood time when it travels higher in the canyon, at greater speed, and carries more sand and sediment, the tools of fluvial sculpture. During the late spring and all summer both rims of the canyon are accessible by automobile.

Dinosaur National Monument, Colorado-Utah: Scale, 1: 62,500; contour interval, 50 feet. Single sheet, 75 cents.

This edition of the topographic map of Dinosaur National Monument was prepared in cooperation with the National Park Service. A comprehensive illustrated ac-

count of the geology, history, geography, and plant and animal life of the area has been printed on the reverse side. The monument was established in 1915 by proclamation of President Woodrow Wilson. It was enlarged in 1938 and now embraces about 200,000 acres bordering the deep canyons of the Yampa and Green rivers.

Available free upon request to the U. S. Geological Survey is a check list, with prices, of topographic maps of the National Parks, monuments, and historic sites. These maps are of great value to anyone interested in the natural features, geology, and history of such areas, or to those planning hiking or pack trips. A few are done in shaded relief. They indicate the boundaries, mountains, hills, valleys, mountain passes, glaciers, trails, lakes, ponds, streams, springs, sand dunes, cliff dwellings, ruins, buildings, and other natural and man-made features.

Standard Topographic Quadrangles

Included among new topographic maps are twelve prepared by the Tennessee Valley Authority in cooperation with the Geological Survey, covering quadrangles in Tennessee and Alabama. This cooperative program was started in 1933 at about the same time TVA was born. It is intended to provide complete topographic map coverage of the valley from headwater sources in the mountains of Virginia, North Carolina, Tennessee, and Kentucky to confluence with the Ohio River at Paducah, Ky. At present more than 85 per cent of the total area has been mapped, and the remainder of the quadrangles are well on the way to completion.

The complete list of new maps as published by the U. S. Geological Survey (about 70 each month) is contained in the monthly pamphlet *New Publications of the Geological Survey,* available free upon request.

Reprinted Topographic Maps of Special Importance

The following maps have been reprinted:

Alaska
Base map A* (ten cents)
California
Mount Baden Powell*
Illinois
Dixon*
Illinois-Missouri
Pearl*
Maine
Buxton*
Missouri
Edgehill*
Meramac Springs*

New Mexico
Taos and vicinity
New York
Paradox Lake
Oregon
Dutchman Butte†
Puerto Rico
Carolina*
Mayaguez*
Rio Grande*
Virginia
Charlottesville*

* Reprinted with corrections.
† New shaded-relief edition.

All standard topographic maps of the USGS are available at 20 cents each. An information folder on mapping; an index to topographic mapping in the United States; and indexes to any of the various states, Alaska, Hawaii, or Puerto Rico will be mailed free upon request. New indexes have recently been published for Alaska, Arkansas, Hawaii, Illinois, Kansas, Minnesota, Missouri, New Mexico, New York, North Carolina, Oklahoma, and Wisconsin.

Maps of areas *east* of the Mississippi River may be ordered from the Chief of Distribution, Geological Survey, Washington 25, D. C. Maps of areas *west* of the Mississippi may be ordered from the Distribution Section, Geological Survey, Denver Federal Center, Denver, Colo.

Prepayment is required and may be sent by money order or check, payable to the Geological Survey, or in cash—the exact amount—at the sender's risk. On orders amounting to $10 or more at the retail price, a discount of 20 per cent is allowed. A net price is quoted for those maps on which no discount is given.

In addition, the following status index maps on a scale of 1:5,000,000 may be obtained on application:

Status of topographic mapping in the U. S. territories and possessions (2nd ed., 1950). This is issued as two maps: Map A, showing areas covered by maps at the scale of 1 inch = 1 mile or larger; Map B, showing areas covered by maps at scales smaller than 1 inch = 1 mile.

Status of aerial photography in the United States (5th ed., 1951). Shows by color patterns or outlines the various government agencies holding the films, as well as showing areas in which films held by state or commercial organizations are available to the public.

Status of aerial mosaics or photo maps in the United States (2nd ed., 1949). Includes information on the various agencies holding the films.

Status of horizontal control in the United States (1st ed., 1948). Shows by line and color pattern the areas covered by triangulation and transit-traverse surveys of Federal agencies.

Status of vertical control in the United States (1st ed., 1948). Shows routes of all level lines reported to date by Federal agencies.

Geologic Maps, Sections, and Indexes

Professional Paper 222: Extra copies have been printed of Plate 1, Sheets 1–5 (geologic map) and Plate 2 (geologic sections) from Professional Paper 222, Geology and Paleontology of the Santa Maria district, Calif., by W. P. Woodring and M. N. Bramlette. Plate 1 is $1.50 for the five sheets; Plate 2 is 50 cents. Both prices are net. The complete report is available only from the Superintendent of Documents at $2.25 per copy.

Geologic Map Index of the State of Arizona, compiled by Leona Boardman. Scale 1 : 1,000,000 (1 inch = nearly 16 miles). 1 sheet, 29½" × 32", 35 cents.

BOOK REVIEWS

FACTS OF LIFE

Human Fertility: The Modern Dilemma. Robert C. Cook. viii + 380 pp. $4.50. Sloane Associates, New York. 1951.

AS WE study the period before the Renaissance, one of its most striking characteristics was human ability to see things that were not there: witches, warlocks, devils, personal spirits, etc. It is possible that the historian looking back at our alleged scientific age will find equally impressive our incapacity to see the things that *are* here.

Taking refuge behind verbal brier bushes, moderns not only deny the existence of as diverse realities as gene patterns and runaway increases in populations of hungry human beings, but (like their thirteenth-century predecessors) persecute those who will not accept the authority and finality of some particular Word. Their power seems incredible until one sees bowing before it scientists (who, with their integrity lost, are lost men), great legislative bodies, international organizations, and even military heroes. Beneath the smog of words the reality of processes rushes swiftly on, and there would be little hope of escape from our refusal to face reality were it not for an occasional individual, like the author of this book, who is not afraid to violate taboos. Possibly—just possibly—such realism will help us save the good things that man has devised in our civilization.

Mr. Cook (on whose work has already been plastered the label "immoral") has courageously tackled the problem not only of population quantity, but of population quality. His facts are the facts of daily heartbreak, hunger, despair—and hope—with which hundreds of millions of human beings live as intimately as do most of us comfortable Americans with our daily orange juice and hot baths. He shows us not only how genes act, but how the minds of men (where the solutions must be found) act, and the juggernaut of desperation that man's lopsided thinking has set rolling. His solution is not, as one eminent general has urged, less science, but more.

The book is full of quotable, illustrative anecdotes. One of the wriest, and most timely, might be cited. It describes the Hero of Bataan quailing before the Catholic Women's Clubs of Tokyo and writing them: "In order to prevent any misunderstanding . . . the Supreme Commander wishes it understood that he is not engaged in any study or consideration of Japanese population control." Thus the Great Administrator, in the face of the 5,000 more Japanese who take their place at the American breakfast table every morning, largely as a result of the Supreme Commander's policies!

There may be more important books published in 1951 than this one, but it does not seem likely. *Human Fertility,* with scientific soundness and high readability, discusses the most powerful limiting factor operating in human society today—and suggests how to control it.

WILLIAM VOGT

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THE SOVIET PHYSICAL ENVIRONMENT

Geography of Russia. N. T. Mirov. xii + 362 pp. Illus. $6.50. Wiley, New York. 1951.

AS RECENTLY as fifteen years ago English-language materials on the geography of the Soviet Union were almost nonexistent. Since World War II, however, new books on Russian geography have been making their appearance with increasing frequency. One of the latest is by N. T. Mirov, a Russian émigré scholar, currently lecturing on Soviet geography at the University of California. In the preface of his *Geography of Russia,* Mirov announces that his intention is "to steer a course between the extensive coverage of L. S. Berg's monumental volume and the exclusively popular styles of some of the less scholarly authors." He is writing with "the college student primarily in mind," but with the hope that his book will also be read "with pleasure and profit by the interested layman."

In his effort to achieve this precise and difficult goal, Professor Mirov decided to exclude the economic aspects of Russian geography, with the remark that "the scarcity of available data precludes an adequate discussion of this feature." It is an author's privilege to exclude whatever he pleases from his manuscript, but it is only fair for this reviewer to remind readers of THE SCIENTIFIC MONTHLY that many writers within the past decade—among them, Bergson, Cressey, Jasny, Katkoff, Ropes, Schwartz, Shabad, and Volin in the United States, Baykov, Dobb, Gray, Gregory and Shave, and Turin in Great Britain, George Jorré in France, and Leimbach in Germany—have written competently and at length on Soviet economics and economic geography. In addition, we now have an English translation of a prewar university-level textbook in economic geography written by Soviet authors, made available by the Russian Translations Project of the American Council of Learned Societies. Perhaps it was, rather, the abundance of material with an economic emphasis that led Mirov and the publishers of this book to confine its subject matter primarily to physical geography.

Part I, in about 50 pages, presents the "General Picture of the Country" with short chapters on Location, Geology and Topography, Climate, and Rivers and Lakes. Part II, "The People," is an even briefer survey of Historical Geography, Peoples, Languages, and

Religions, including among other things an interesting and unusual map showing the distribution of blood types. Part III, comprising about three fourths of the book, is a systematic presentation of the pertinent facts of topography, climate, soils, natural vegetation, and wild animal life for twenty so-called natural regions. These regions, based partly on vegetation zones and partly on relief, follow in general the divisions established by L. S. Berg, dean of Russian geographers, whose death a few months ago ended more than half a century of scientific scholarship. Mirov acknowledges his obvious indebtedness to *The Great Soviet Atlas,* and to such Russian geographers as Berg, Baransky, and Suslov. Indeed, the appearance of Berg's *Priroda S.S.S.R.* in an English translation last year substantially lessens the need for a book such as the one under review.

Mirov has done a competent, workmanlike job of presenting the main outlines of the physical geography of the Soviet Union. His regional chapters include a wealth of information on plant and animal life, for which biologists and biogeographers will be especially appreciative. The book is illustrated with 34 well-selected and clearly drawn maps.

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POPULARIZING ENTOMOLOGY

Insects in Your Life. C. H. Curran. 316 pp. Illus. $3.50. Sheridan House, New York. 1951.

IT IS A pleasure to read a book by a scientist who has done original work; so many recent books have been compilations. *Insects in Your Life* is an interesting account of the home and garden insects with which the average person comes in contact. Dr. Curran, curator of insects and spiders of The American Museum of Natural History, shows how dependent man is upon insects. He writes of their importance in pollinating food plants and flowers, as beneficial enemies of destructive insects, as scavengers, and as food for fish and birds. Curious habits of insects that carry dangerous diseases of man and animals and of those that are pests of man's food plants, animals, home, and possessions are colorfully described. He tells us, too, what to do about them.

Discussions of flies that are parasites of spiders, and of those with eyes on stalks, lead to a vivid account of his outstanding study of the flight of flies and their "gyroscopic" organs, which may help man in designing airplanes. There is a fascinating description of the tropical human botfly and its curious method of survival. The chapter on eating insects as food should intrigue but not convert the layman to that type of fare. Some of the insects of prehistoric time were giants compared with even our largest living insects, such as the remarkable mouse-eating grasshopper. Dr. Curran's account of the insects of Barro Colorado Island, that important research station in the Panama Canal, should stimulate public interest. Excellent photographs and drawings enhance these stories.

The entomologist will disagree with the "northerly spread of termites" and the statement that they shun bright light; they require humidity rather than darkness. The woolly bear caterpillar's black-and-red bands have their relative width determined by past, not future, conditions and do not predict the weather. The reference to the spraying of the island of Saipan with DDT, the "atomic bomb of the insect world," is an unfortunate example of the danger in the use of that chemical. Amounts were sprayed far in excess of the dosages used with safety today, resulting in serious losses of animal and plant life.

Dr. Curran is a splendid naturalist—an outdoor man—as one who has seen him in the jungle knows. His book is eminently readable and thus should be valuable in popularizing entomology.

THOMAS E. SNYDER

Washington, D. C.

LOGICO-MATHEMATICS

Field Theory in Social Science. Kurt Lewin (edited by Dorwin Cartwright). xx + 346 pp. Illus. Harper, New York. $5.00. 1951.

"WHEN the intellectual history of the twentieth century is written, Kurt Lewin will surely be counted as one of the few men whose work changed fundamentally the course of social science in its most critical period of development." In these words Dorwin Cartwright indicates Lewin's significant place in the growth of twentieth-century science.

This is a highly important book. It will be welcomed by former colleagues and students of the late Kurt Lewin as a convenient and skillfully edited compilation of his scattered papers. In addition, several other types of readers should find the book useful. Among those persons who might not otherwise be tempted to open the volume, but who will find it illuminating if they do, are some students of the so-called exact sciences. It is recommended to those who may regard social psychology, sociology, or human ecology as fuzzy, undisciplined disciplines filled with data of unorganizable complexity, and utterly lacking in rigorous logico-mathematical methods by means of which data may be ordered and measured.

Other potential readers who will probably find the book valuable—perhaps irritating—are those researchers who are strong for scientific method and measurement so long as measurement is limited to statistical terms. To them it will bring at least two other kinds of mathematics, in addition to statistics.

Still another, and probably larger, class of potential readers might pass up this book when they see that it treats of theory. Such practical or empirically minded persons may resist the intrusion of theory, as if the word "theory" is somehow joined with the understood prefix "mere" into one word, in much the same way that "damyankee" was formerly used in certain regions of the U.S.A. Such persons, before they decide that this book has nothing for them, may be reminded of

the words of J. Willard Gibbs, the pioneering physicist-mathematician whose theoretical work in thermodynamics pointed the way to many of the striking advances now accepted as matters of course in present-day physical science. Said Gibbs: "It is the office of theoretical investigation to give the *form* in which results of experiment may be expressed" (italics mine). Gibbs' words may also be applied to Lewin's field theory, though the Lewin approach is a psychological rather than a physical one.

This book is the second volume of collected writings of Kurt Lewin. It might well serve as a companion volume to the first collection, which was published in 1948 under the title *Resolving Social Conflicts*. Both volumes present Lewin's system of thought, but the earlier volume deals primarily with the applications of Lewin methodology to practical problems of society. Despite minor duplications, the two volumes complement one another.

In addition to a foreword and preface, *Field Theory in Social Science* contains ten chapters, an appendix, an index, and bibliographies at chapter endings. The subjects discussed, with terms defined, are suggested by these chapter headings: Formalization and Progress in Psychology; Constructs in Field Theory; Defining the "Field at a Given Time;" Field Theory and Learning; Regression, Retrogression, and Development; Field Theory and Experiment in Social Psychology; Psychological Ecology; Frontiers in Group Dynamics; Behavior and Development as a Function of the Total Situation. The appendix deals with an analysis of the concepts Whole, Differentiation, and Unity.

The value of Dorwin Cartwright's foreword can hardly be overemphasized, especially to readers in need of orientation toward Lewin's formal and precise, hence often difficult, system of thought. In language remarkably clear and simple, considering the complexity and abstract nature of the subject, the editor gives a straightforward what-it's-all-about introduction to Lewin's papers collected here.

Just what do these papers contain? What have Lewin and his colleagues contributed here to the formalization and understanding of data on man's behavior in society? In what ways does the Lewin field theory mark an advance over older social science theories as to comprehensiveness, measurement, or general usefulness?

A general answer to these questions may be stated in pragmatic terms. *Field Theory in Social Science* deserves wide reading, as well as close study, because its great contribution lies in the general direction of making social scientists more productive. More specifically, here are twelve points that briefly summarize the chief features of that contribution:

1) The Lewin field theory deals with force fields.
2) Analysis begins with the situation as a whole.
3) This theory makes use of a "constructive method" (i.e., utilizing logico-mathematical constructs) rather than a classificatory method.
4) It marks "a distinction between systematic and historical problems."
5) It lends itself to operational definitions and focuses interest on the dynamic aspects of events.
6) It utilizes "a mathematical representation of the field."
7) The Lewin field theory is more a fruitful "approach to the scientific task than a theory about a realm of data." It formulates the major attributes that characterize the working methods of any productive social scientist, regardless of his theoretical orientation.
8) It explains how "the work of the scientist consists of making a proper translation from phenomena to concepts."
9) "It permits the treatment of both the 'qualitative' and 'quantitative' aspects of phenomena in a single system," and thus "allows both generalization to universal laws and concrete treatment of the individual case."
10) It deals adequately with causal relationship in *a single case*—a realm in which scalar measurement alone does not apply. In other words, here is a method of representing "the conditional-genetic (or causal) attributes of phenomena" by bringing out the dynamic interdependencies of those attributes within a single system or case.
11) It facilitates the "measurement . . . of these attributes."
12) The Lewin logico-mathematical field theory may be used to great advantage in that persistent problem, the design of experiments. Listeners to reports on experiments at scientific meetings may suspect that there are still some researchers who work prodigiously with mathematics in the form of statistics, but fail to use other forms of mathematics in the designing stage of their experiments.

This book makes abundantly clear the point overlooked by such researchers: that even prolonged statistical treatment of the data of disorganized complexity cannot be depended on to overcome the handicap of inadequate design of the experiment in the first place. To such specialized workers in the vineyard of science this book may come as a disturbing challenge; but it may also open up new vistas.

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BEFORE MEN CAME

Deciduous Forests of Eastern North America. E. Lucy Braun. xiv + 596 pp. Illus. $10.00. Blakiston, Philadelphia. 1950.

THE appearance of a book bringing together the results of a lifetime of work by a competent scientist is an event of interest and importance. Such a book is the long-awaited treatment of the deciduous forest by Lucy Braun, and it is a rare privilege to read and review a work of such quality and interest as this one.

Most or all aspects of the science of vegetation are so controversial that one can scarcely expect that the wor

of any one student will completely satisfy any other. And it is difficult to write a review that will be objective and uncolored by one's own background, opinions, and prejudices. A scientific book may be fairly judged on five bases: (1) adequacy and accuracy of subject matter, (2) soundness of concepts, (3) effective application of concepts to subject matter to produce interpretations, (4) effective presentation or literary quality, and (5) quality of manufacture.

No one will be likely to question that, as to subject matter, Lucy Braun's knowledge of the Eastern deciduous forest is unequaled. Indeed, from this point of view the book is almost encyclopedic. She describes, from wide field acquaintance, the forests in every section, reconstructing them as they were before ax, fire, and chestnut blight. The geographer, as well as the forester, botanist, and ecologist, will regard this as the basic work of reference on the condition of the continent before the advent of man. Special attention is not given to the results of man's activities, but the reader is kept reminded of them. A feature that is especially good is the presentation in tabular form of the composition and abundance of trees in individual stands of forest in all regions. A type of table is used that makes grasp and comparison easy.

In the matter of concepts, there seems little doubt that most of those used in this book are essentially sound. In some cases their presentation has left something to be desired. There seems to be an assumption that the reader will have the same ecological philosophy as the author. The terminology of Clements has been accepted and used without comment. The climax concept has been employed throughout the book, apparently accepted as a reality. It is only in the last chapter that the artificiality of this idea is recognized, even though the facts presented throughout the book demonstrate this very effectively. It is hardly probable that this overuse of the term climax can do otherwise than exaggerate its significance in the minds of both author and reader. Further explanation of what is meant, on page 448, by the "phylogenetic relationship" of a plant community might make this usage less questionable.

One cannot help regretting the use of some of the soil-science ideas and terminology given in Chapter 2. This is obviously more a reflection of the state that this science has got itself into than any special lack of understanding on Professor Braun's part. The fact that no one system of soil classification was adequate to express what she needed to say is significant. It seems, to one who learned his soil science in the good old days when podzolization was not merely a synonym of leaching (*cf.* p. 25), when laterization was an antithesis of podzolization, when *glei* was a layer produced by alternate freezing and thawing over frozen subsoil, etc., that understanding has been obscured rather than clarified by those Dr. Braun has followed.

In general, the brevity of presentation of the author's ecological concepts has left some questions, but this was doubtless the most effective way to avoid the morass of current ecological philosophy and terminology.

The interpretation of the deciduous forest in terms of its existing remnants, historical and fossil records, dynamic physiography, and geological history is an outstanding accomplishment. The author draws freely on the work and opinions of others, as acknowledged in the extensive bibliography and innumerable text references to it, but her final interpretation is her own, and will doubtless endure very well as new knowledge accumulates.

Her writing is clear and easy reading, though perhaps not brilliant. Compared with that of many of her ecological colleagues, it may do a good deal toward making ecology a more popular and better understood science.

The typography is good, errors remarkably few, and the book, though of almost 600 pages, is of a very handy size. An index to plant names and a subject index are provided. The abundant photographs illustrating practically every variation of every forest association are excellent. It is a pity that their reproduction leaves something to be desired. One is inclined to wish he could see a set of the original prints. Most of them are by the author.

In over-all evaluation of this book, one can only say that it is a definitive work, and that it has reached a level of excellence seldom or never before attained in American ecology or vegetation science, at least in any work of comparable importance. It may be rather too comprehensive to be used as a text in any but the most advanced courses, but from now on it will unquestionably be the standard reference on the vegetation of eastern North America. Its distinguished author is to be congratulated and thanked.

F. R. Fosberg

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FUNDAMENTAL DATA

Marine Geology. Ph. H. Kuenen. x + 568 pp., 2 plates, 246 figures. $7.50. Wiley, New York; Chapman & Hall, London. 1950.

GEOLOGISTS have long depended on the deductive reasoning of such writers as Barrell, Grabau, Davis, and Johnson to interpret the sedimentation and stratigraphy of marine and littoral beds. This dependence was inevitable, for factual data from the sea floor has come at a price of a thousand dollars a bucketful, and the physical and mathematical analyses of current and wave dynamics have not been readily available to, nor understood by, most geologists.

Widespread interest in present-day work on the floors and shores of the sea has been stimulated by Shepard's recent readable *Submarine Geology,* which especially stresses morphology. Fundamental data on all phases of oceanography have been compiled and interpreted from the point of view of the oceanographer in *The Oceans,* by Sverdrup, Johnson, and Fleming. The gap between these two excellent publications is bridged by Kuenen's *Marine Geology,* which should prove of even greater value to most geologists because he has not only compiled a vast amount of data col-

lected by expeditions and workers over the world, but he has interpreted marine processes and has stressed the problems to be solved from the point of view of a geologist of wide experience.

The book is well organized, in its larger aspects and in compilation of data, and it is well illustrated by graphs and figures, although no half-tone plates are used. Discussions refer fully to the work of others, and many references as recent as 1948 are included. It is to be hoped that the eventual publication of the results of highly successful oceanographic work done since 1948, and the release of much now-classified work done earlier, will result at a later date in a revision and expansion of this book.

Discussions are comprehensive and detailed, but some are poorly organized, with a resultant lack of emphasis. Many short statements of critical interest are immersed in the text and are apt to be overlooked, especially by a reader without much background in submarine geology. On the whole, though, the book is readable and stimulating, and it should be welcomed by geologists in many fields.

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LIFE'S ORIGINS

The Emigration of Animals From the Sea. A. S. Pearse. xii + 210 pp. Illus. $5.00. Sherwood Press, Dryden, N. Y. 1950.

FRIENDS of A. S. Pearse will welcome this revised edition of his interesting account of the greatest migration of all times. The story of life's origin and the slow and complex emigration of animals from the sea to land is in great part an ecological study. This book will serve more as supplemental reading for students of zoology than for the interested layman.

Dr. Pearse has outlined the routes from the sea, the various causes of emigration from the sea, and how animals have changed. Throughout his treatment of controversial subjects, he has quoted extensively from workers supporting opposite views. As the original home of life, as much can be said in favor of the ocean as for marshy or purely fresh-water localities. In his discussion of the several routes from the sea, Pearse favors the sea beach route, and claims that few animals have reached fresh water, and thence land, by migrating through estuaries. He does not speculate on the equally justifiable possibility that his "indicative" beach inhabitants are merely lateral migrants from various ecological zones of the estuaries. Few students of mollusks, insects, or worms would support the idea that a direct march was made through the surf up the inhospitable slope of the sea beach.

The bibliography, now brought up to date and corrected, has more than 900 valuable entries. It is surprising that a book of this size should contain so many bibliographic references in the text. Readers not familiar with the style of ecologists will find some of these rather burdensome. One wonders if some of the credits are really necessary, or if earlier writers have not been overlooked when modern citation is given for such statements as "Success is continual improvement (Pearse, 1926a)" or "Land vertebrates are often carnivorous (Pearse, 1932a)."

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MODERN GENETICS

The Principles of Heredity. Laurence H. Snyder. (4th ed.) xi + 515 pp. Illus. $4.75. Heath, Boston. 1951.

FIFTY years after the rediscovery of Mendelism the experimental subject of genetics is still developing so rapidly that frequent revisions of texts on heredity are found necessary. To digest and evaluate the plethora of new researches that appear annually in scientific periodicals, and to choose the most suitable examples indicative of new theoretical advances for recording in the revision of genetics books, is no small task in itself. Such a job, well done, not only assures the continued popularity of a particular text, but also serves as a boon to teachers of courses in heredity.

Most college teachers of heredity are not experimental geneticists by profession. They do not have genetic literature available and they do not possess the time to explore library shelves; nevertheless, they are anxious to keep their genetics courses as up to date as possible. Snyder's book has always been popular with these teachers because of its clearness of style, simplicity of expression, the enthusiasm of the author, and its human emphasis. The fourth edition is a normal advance over previous editions.

In this edition the misleading expression "genetic factor" gives way to the exact term "gene." Our knowledge of hereditary variations in mammals and the subject of blood groups have been modernized. Mutagens, gene chemistry, and gene physiology acquire more emphasis. Sex determination, as well as enzyme production and control by genes, is discussed under How Genes Act. The sections on man have been rewritten, extended, and materially enhanced.

The third edition format was staid, the cover design Victorian-decorative. The fourth edition, in contrast has gone modern. On its cover is a large, mature egg about to be fertilized. College wags will smile when they note that the egg is labeled "Snyder."

All in all, one may predict that the fourth edition of Snyder's genetics text will find great favor.

CLYDE EDGAR KEELER

Georgia State College for Women

LETTERS

FORECASTING WATER YIELD

Dear Sir:

Dr. Wilm is to be complimented on his informative discussion of some of the problems in water-supply forecasting (*Sci. Monthly*, **72,** [1950]). At some risk of being misunderstood, it seems pertinent to amplify, for the casual reader, some aspects of this important subject.

As Dr. Wilm stated, many individuals and organizations are participating in this "business." Irrigation districts, dam operators, municipal power companies, and Federal agencies having special interests in various parts of the West make their own estimates for many localities. The U. S. Weather Bureau prepares water-supply forecasts for several hundred key points throughout the West, and these forecasts are published in bulletin form as of the first of each month, January through May. A combination of numerical and graphical methods, which is particularly effective in highly correlated joint-curvilinear relationships, is used in preparing these forecasts.

In discussing the use of regression in forecasting, perhaps it should be stated that the assumption of randomness or normality is not inherent in the use of least squares. It is the *t*-test which requires the assumption of normality.

It may be noted in Table 2 of Dr. Wilm's paper that, for each year after 1939, when the earlier data are dropped, the forecast was lower than the observed water yield. This bias could be ascribed to chance, or even to the arbitrary weighting of snow courses by elevation alone. However, there are methods such as double mass analysis which make it possible to utilize the entire period of record, thus exploiting the obvious advantage which Dr. Wilm has aptly pointed out—that of a long record and many degrees of freedom.

In thorough and continuing studies of many variables, the Weather Bureau has found that several of those mentioned by Wilm are definitely important. This is particularly true of autumn and spring precipitation, which are weighted along with winter precipitation in relations developed by the Weather Bureau. Paradoxical as it may seem, it has been found that good forecasts of seasonal water supply do not require observations of the snow pack itself. The Weather Bureau relations rely on the advantages of measuring all the precipitation, including snow, in impervious gauges equipped with windshield and provided with antifreeze and an oil film. The purpose of the oil film is to minimize evaporation, which would be important during warm weather.

Walter T. Wilson

Weather Bureau Office
San Francisco

EDITORS ARE HUMAN

I have just read the article in the May number of The Scientific Monthly by Williams and Laurits, "Scientists and Education." To my way of thinking, this is a reasonably satisfactory answer to the Fuller article.

I have heard several persons raise a question as to whether you are entirely neutral in handling the editorial comments on the Fuller article and the replies. On page 282 of the May Scientific Monthly your editorial terminology speaks of a certain number of letters "enthusiastically for" and a much smaller numbers of letters "bitterly against" Dr. Fuller. [We stated only the facts.] On page 344 of the May issue you announce the speaking engagements of Dr. Fuller as a critic of education and offer to furnish free reprints of Dr. Fuller's article. To what extent do you plan to announce the speaking engagements of persons who differ from Dr. Fuller in their views, and will free reprints of the current Williams and Laurits article be distributed?

The facts would indicate that you have gone definitely outside the field of science, the scope of a scientific journal, and the objective method to publish a controversy on an educational problem and that your position appears to be something other than neutral as an editor.

Carter V. Good

Teachers College
University of Cincinnati

WORLDS APART

I have just read the reply to Dr. Fuller by Williams and Laurits, which I feel does not reply at all. They make me think of a yoke of oxen toiling desperately to accomplish a self-imposed task, while Fuller was a race horse, commanding admiration on every hand. Strictly speaking, I do not think they really answer him at all. These two writers talk about education, whereas he had it in for education*ists*. Much that they say is good, but there is so much in the background that they ignore. I do not recall any two articles which shot by each other as these two do.

Gregory D. Walcott

Department of Philosophy
Long Island University

℞ CUM GRANO SALIS

I am very much interested in the early explorations of the Atlantic coast of North America and was pleased to see William Herbert Hobbs' "The Fourteenth-Century Discovery of America by Antonio Zeno" in the January 1951 issue of The Scientific Monthly.

I do not agree entirely with his conclusions concerning Drogeo, however. Undoubtedly, as he suggests, it was in Nova Scotia, and the "pitch" found there was the oil shale of Pictou County; whereas, however, Stellarton is well known as a coal mining town, it is not known locally as the "Asphalt District."

According to the story, 100 soldiers were sent from

Tor Bay to explore the country, and they walked in a northwesterly direction, through an extremely rugged and densely wooded country, to the "Smoking Mountain," near Antigonish 45 miles away; then turned west and walked another 45 miles through equally rough country to Pictou Harbor; then ascended the East River 15 miles to the oil shale deposits; and then they returned to the ships in Tor Bay—about 210 miles, all in eight days. Allowing a little time for exploring, they must have walked an average of at least 30 miles per day through unknown country—an incredible feat.

The Micmacs were continual "tourists," crisscrossing Nova Scotia and New Brunswick with canoe and portage routes, and there is every reason to believe that Zeno's men followed one of the old Indian trails.

It is true that Nova Scotia has a low relief, but the entire province is mountainous or hilly, and almost anywhere it is possible to see at least one mountain that stands out prominently. On the other hand, the Antigonish Mountains cannot be seen from Tor Bay or from anywhere else on the eastern shore. Naturally, the smoke the men saw was from a forest fire.

I believe the ships approached the coast about 40 miles west of Tor Bay and entered the estuary of the St. Mary River, which is navigable for 10 miles to the village of Sherbrooke and is an excellent harbor. The scouting party probably ascended the East River St. Mary to Eden Lake, from whence there was a short portage of about one mile to Beaver Lake, the source of the East River of Pictou. This they followed, passing the exposed coal and oil shale seams at Stellarton, to Pictou Harbor. The distance from Sherbrooke to Pictou and back by this low-level valley route would be about 140 miles and could be done very easily in eight days.

Pictou County is not noted particularly for the existence of natural caves; I know the area well but have never seen or heard of any. And likewise the Micmac Indians are not known as small and timid cave dwellers. Mentally and physically they compare favorably with other tribes.

ROBERT R. BROWN

Pointe Claire 33, Quebec

POSTSCRIPT FOR PEATTIE

MY REMARKS in my review of Peattie's *Natural History of Trees* (*Sci. Monthly,* **72,** 133 [1951]) that "some of the stories are highlighted with at best only good historical guesses," and that "much of the detail for the travels and times of Michaux is still very incomplete and any conclusions as to where such and such a tree was first discovered is yet to be documented from a broad synthesis of evidence," were based on the fragmentary stories centering about Fraser, Lyon, Enslen, Baldwin, and many another contemporary of Michaux. Although André Michaux is unusually well known in this coterie, I mentioned Michaux because he is familiar to more readers. However, even for Michaux we are often uncertain of details. For example, when Peattie writes of the "Southern Balsam" fir (pp. 59–60) he tells of John Fraser's meeting André Michaux at Charleston and of their botanizing together. He says the discovery of the fir (*Abies fraseri*) was the outcome of Fraser's pushing on to the very summits of the Appalachians when Michaux, distrusting Fraser's motives, and fearing his rivalry in the discovery of novelties, fell behind on the journey and thereby missed the prize. Aside from the discrepancies in the story as told by Peattie (Michaux' version) and by Fraser (1789), it is only an inference that the fir was actually discovered on this particular journey! Fraser himself tells of traveling 400 miles and that he "visited also part of the mountain towns," but I find no conclusive evidence affirming, and some suggestions disproving, this coincidence.

Loudon says (1844) that *A. fraseri* was introduced into English horticulture in 1811, more than 22 years after this trip with Michaux. It seems to me highly unlikely that Fraser, as a nurseryman and dealer in novelties, would have so long delayed the introduction of the new fir when it was clearly to his advantage to hurry discovery of the new tree into English gardens. Pursh writes (1814) that Fraser found the fir on the "high mountains of Carolina," and that he saw the dried specimen in Lambert's herbarium. Lasègue (1845) states that Fraser made a trip in 1799 with his son, John Fraser, to points in the southern Appalachians up to that time unexplored and that they reached "Great-Roa or Bald Mountain." Possibly this was the year of the tree's discovery. Again Fraser may have found the tree on one of the last of his trips into the southern Appalachians; there are letters in the Lindley correspondence in London that may throw light on this. In short, the problem is complicated by the paucity of published record, and because the ms. materials are little known. Disraeli said that "it is much easier to be critical than to be correct," and I lack definite proof that *A. fraseri* was discovered some years after Fraser's meeting with Michaux, but I am dubious of the story as Peattie has told it. Clio's cloisters have many crannies!

The *Natural History of Trees,* I repeat, is an engaging narrative replete with interesting fact and well-told anecdote. The scientific reader will "read neither to believe nor deny but to weigh and consider."

JOSEPH EWAN

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